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SHORT-TERM WHEAT YIELD FORECASTING IN EGYPT: AN ASSESSMENT

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LIST OF ACRONYMS

ADCAP	Agricultural Data Collection and Analysis Project
AERI	Agricultural Economics Research Institute
APRP	Agricultural Policy Reform Program
ARC	Agricultural Research Center
CAAE	Central Administration for Agricultural Economics
CAAP	Central Administration for Agricultural Planning
CIMMYT	International Center for Maize and Wheat Yield Improvement
DOS	Directorate of Sampling
EAS	Economic Affairs Sector
ESA	Egyptian Survey Authority
FAO	Food and Agricultural Organization of the United Nations
GDAS	General Directorate of Agricultural Statistics
GOE	Government of Egypt
ICARDA	International Center for Agricultural Research in Dry Areas
MALR	Ministry of Agriculture and Land Reclamation
MPWWR	Ministry of Public Works and Water Resources
MVE	Monitoring, Verification and Evaluation Unit (APRP)
NASS	National Agricultural Statistics Service (USDA)
NWRP	National Wheat Research Program
PSU	Primary Sampling Unit
USAID	United States Agency for International Development
USDA	United States Department of Agriculture

Ha	Hectare
T	Ton
Gm	Gram
Fd	Feddan
M	Meter
Cm	Centimeter
M^2	Square Meter
Kg	Kilogram
N	Nitrogen
P_2O_5	Super Phosphate
LE	Egyptian Pound

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EXECUTIVE SUMMARY

Egypt's population is increasing, and the demand for food is growing. A major challenge for the future is managing the country's food production capacity and other sources of food supply. This strategy requires reliable and timely information on which to base policy decisions. Wheat is a major food staple. Annual consumption is between 12 and 13 million tons or about 190 kg per capita. Currently, domestic production accounts for about half of the need, and the remainder is imported.

There are several reasons why forecasting wheat yield and production are very important to Egypt: 1) The GOE operates a major program to produce and distribute subsidized *baladi* bread and flour. It buys wheat from farmers, and also imports large amounts of wheat from abroad. Thus the GOE could benefit from early information on production that could be used in estimating both its procurement quantity and its import requirements, 2) There may be some price cycles in world markets. Having estimated production and its import requirements, the GOE might be able to take advantage of lower import prices at certain times of the year, 3) Large commercial wheat millers and wheat importers have a major interest in information on wheat production. While they are not allowed to purchase domestically produced wheat, the amounts produced by farmers and bought by the Government will influence the amount to be imported by the private sector and 4) Small wheat traders and grinders purchase wheat from farmers. These individuals also have a strong interest in knowing how much wheat is likely to be produced. Many small traders trade a variety of commodities, changing their operations depending on the supply and demand conditions for each commodity. Early information about wheat production will allow them to focus on those commodities where their services are most needed.

The main objectives of this study were to:

- Assess the quality of wheat yield forecasts being made in the MALR, and
- Recommend an appropriate method(s) to be adopted by the MALR.

It should be mentioned that this study was not intended to produce reliable forecasts of yield for the current year, but to test the methodology and procedures for early season forecasting.

The study team visited Noubaria and six governorate sampling offices, Kafr El Sheikh, Gharbia, Beheira, Fayoum, Beni Suef, and Assiut in November and December 1999 to assess existing wheat yield forecasting procedures. The team also visited four agricultural research stations: Sakha, Gemmiza, Noubaria and Assiut.

During these visits sampling office officials were asked to comment on survey activities (including forecasting), procedures, training, and cooperation with other government offices, resource needs, and level of support. Researchers at the stations responded to questions about their willingness to assist with the training of sampling office enumerators in preparation for the pilot field survey, and in setting up training facilities at the stations. Farmers, extension agents and the director of a cooperative were also interviewed. The team's assessments are based on documents from previous studies, interviews, opinions, observations and MALR institutional knowledge.

With the strong support of EAS, pilot program was conducted in the six governorates and Noubaria to test potential data collection methods for objective yield forecasting. The governorates in the study, Sharkia, represent the major wheat growing areas and produce the three genotypes of wheat grown in Egypt. Noubaria was included to represent the New Lands. Plots were laid out in sample fields in late January and revisited during the last 10 days of February, March and April to collect plant counts and measurements to drive the forecast models. The plots were harvested for the final yield calculation when the plants reached maturity.

Findings

The needs for reliable and timely statistics on wheat, particularly pre-harvest yield forecasts, have outgrown the capabilities of the present system. The crop-cutting experiment system has remained virtually unchanged for many years. Although past attempts at yield forecasting have been short-lived, the time seems right to begin such a program on a national scale.

Sampling, Data Collection, Processing and Review. The sample size for the national crop-cutting exercise is extremely large. Data collection is a lengthy and labor-intensive process that produces large volumes of data to be handled. Processing is done by hand, and review and checking procedures are inconsistent. Frequent and sometimes large changes are made in the estimates as they move to higher levels. As the review moves farther away from the data source, changes likely reduce accuracy. Changes usually raise the estimates.

Quality and Timeliness of Estimates. A single annual yield estimate, based on crop-cutting surveys, is made in the governorates at the district level and forwarded to EAS. The large sample size should support accuracy. Estimates are available too late to be of maximum benefit to data users. The area estimate usually is published in May, and the yield estimate is available several weeks after the harvest is finished. No quantitative measures of the quality of wheat estimates are undertaken.

Yield Forecasting Procedures

- There is no current program for forecasting wheat yield before harvest.

- EAS has shown a renewed interest in pre-harvest forecasting as a way to improve statistics on wheat.

- Governorate sampling office staff demonstrated the willingness to learn the new methodology and the ability to carry out the survey procedures when properly equipped and trained.

- Meanwhile, researchers from the agricultural experiment stations provided valuable training in the characteristics and growth habits of wheat and factors that affect productivity. Their assistance prepared field enumerators to better understand and interpret conditions they saw in the field. The researchers also provided helpful insights into factors that need to be researched in the future as possible indicators of potential yield.

- *Using the objective yield methods demonstrated, forecasts can be made as early as the end of January to reliably project final yield. However, forecasts become more reliable as the crop advances toward maturity.*

Training. Training was one of the needs mentioned most frequently by the governorate staffs. MALR staff are generally under-trained and at all levels are doing work for which they are not well trained. Many agricultural engineers with long service records have had little or no training in applied statistics or survey methodology. As new engineers come on board, their only training is "on the job". This is a sound concept, but its effectiveness is reduced because of the low skills and knowledge level of existing employees, and it tends to perpetuates any erroneous practices and procedures. The MALR needs to develop an in-service training program for agricultural engineers at the governorate level.

Equipment, Supplies and Support. Transportation, field equipment, office equipment and availability of office supplies need to be upgraded. A shortage of adequate transportation delays the completion of fieldwork. Much of the survey equipment is old, in poor condition and too heavy to carry to the field, especially if the enumerator is traveling by motorcycle. Office equipment is almost nonexistent in most offices. Items such as calculators and adding machines could greatly improve accuracy and work flow.

Recommendations

The recommendations are slanted toward equipping and structuring MALR for crop forecasting. However, the entire statistics program would benefit from their adoption.

Adopt Objective Yield Methods for Pre-Harvest Forecasting of Wheat Yield. Objective yield methodology and procedures are valid for yield forecasting in Egypt and should be adopted all over the country as the main indicator of pre-harvest yield levels for wheat. The sample size is small, but statistically valid, and the turnaround time is short for data collection. The forecasts do not replace final estimates from crop-cutting surveys, but enhance their usefulness.

Initiate an Intensive Training Program. Intensive training will be needed to successfully make the transition to crop forecasting. The proposed training program in this report is designed for personnel in all statistical organizations, but focuses on the needs of MALR. It includes general training in applied agricultural statistics and specific courses on objective survey operational procedures for selected groups of employees based on their area of responsibility. One course is to help managers and policy makers better understand the need for, and uses of, statistics.

Structure MALR for Crop Forecasting. Shifting more responsibility to the governorate offices would improve operational efficiency and exploit field staff knowledge of local conditions.

- Organize and train staff for specific functions. Many functions must be going on simultaneously to meet the tight time schedule from pre-survey planning to release of the estimates. Offices need to be organized to handle the workflow, and staff trained in specific operational procedures. The sampling staff would have responsibility for, and be equipped, for training the governorate personnel.

- Establish survey schedules and release dates. Data requirements should drive the program. Set dates for public release of forecasts and estimates and develop the survey schedule to support those dates.

- Select samples at the governorate level. Each governorate is a domain in the sampling process. Governorate staff should be trained to compute optimum sample sizes and select the samples to derive maximum benefit from their knowledge of local conditions.

- Equip governorate offices with computers. Large amounts of data must be processed in short periods to support objective forecasting. Execution of the forecasting models requires relating current survey data to huge historic databases. It would be impracticable, if not impossible, to make these calculations by hand in a timely manner. Setting up regional data processing centers is an alternative to placing computers in all offices. However, the best possible situation would be for each governorate to do its own data processing, and this should be the long-term goal.

- Enter, review and analyze survey data, and make estimates in the governorate offices. The restructured governorate offices will be capable of completing all functions from sample selection to making estimates when properly trained and equipped. The local staff are in the best position to know about conditions affecting the survey results that need to be considered in the data review and analysis.

- Publish area estimates earlier to enhance the value of early season yield forecasts. Both area under wheat and the yield are needed to determine total production.

- Supervision and quality control. A strong quality assurance program is necessary to assure that proper procedures are being followed. Regional field supervisor positions need to be established to oversee the field and lab work. One supervisor could adequately take care of two or three governorates. The result would be a better-trained staff, improved work flow, greater accuracy, and ultimately, better data quality.

- Refine the program of salary incentives. The MALR has begun a program to base salary incentives on the difficulty of engineers' job assignments and level of performance. Refine and expand this program.

Investigate an Appropriate Sampling Plan for Crop Forecasting. The sampling plan used in the past for selecting forecasting samples is not adequate. The multistage sampling procedure now being used for crop cutting requires that sample units be allocated to every stratum in the sampling frame. This procedure results in a larger sample than is needed to achieve reliable survey results because of the large number of strata in the existing sampling frame.

Expand and Strengthen Cooperation with Other Government Organizations. The study derived valuable benefits from cooperating with the agricultural research stations on training. Local agricultural extension agents have the best knowledge about local conditions and could help field enumerators locate farmers and fields. The cadastral maps in the agricultural cooperatives could also be used to locate farmers and be of assistance in subdividing selected PSUs and parcels.

Research and Development in Applied Agricultural Statistics. Involve AERI in applied research to refine and develop statistical models and operational procedures. AERI staff should be regular participants in survey training programs and could teach the statistics courses proposed in Chapter 6.

Discontinue Incentives for Achieving Higher Yields or Predetermined Targets. This is a disincentive for accuracy and integrity of estimates and tends to encourage an upward bias in the data.

Topics for Future Study and Research

The team recommends that MALR:

- Conduct a study on the modeling response to long-spike wheat varieties. Long-spike varieties are unique for their large number of spikelets, number of grains per head, and high weight per grain among the three genotypes of wheat grown in Egypt. The characteristics of bread wheat and Durum varieties are similar and respond the same way in the forecasting models. However, nothing is known about the response of long-spike varieties, and it needs to be studied.

- Calculate the cost/benefit ratio of crop forecasting. Forecasting surveys are an added cost to statistics programs. Although adequate benefit to justify their use is assumed, research could compare cost to the resultant benefits.

- Investigate Alternative Modeling Variables. Several plant characteristics thought to be correlated with one or more of the components of yield were measured during the monthly field visits. These factors need to be studied to determine if any are stable indicators of the components of yield.

1. INTRODUCTION

Egypt’s population is increasing and the demand for food is growing. Managing the country’s food production capacity and other sources of food supply is a major challenge for the future. Limited land resources are a constraint to large increases in domestic production. Shifting area to food crops from cash crops, and imports are the clearest options available to policy makers. Both of these strategies require reliable and timely information on which to base policy decisions.

1.1 Study Context and Problem

Wheat is a major food staple for Egypt. Annual consumption is between 12 million and 13 million tons. Currently, domestic production accounts for about half of the need and the remainder is imported. During the decade of the 1990’s, imports remained fairly constant at around six to seven million tons a year. The increase in demand due to population growth during this ten-year period was offset by a steady increase in production. If increases in production can continue to satisfy the demand created by population growth, and per capita consumption remains basically unchanged, imports should continue at about six to seven million tons a year for the next few years.

Government decision makers and private traders need reliable information about expected domestic production as early as possible as they make decisions regarding purchases and imports. Currently the final estimate of production is not available until several weeks after harvest is finished, and no organized attempt is made to forecast production before harvest. Therefore, as they attempt to make management decisions, managers and traders, both government and private sector, seek information from many different sources. Due to the lack of reliable official information, data users often turn to speculative sources with no basis in fact for guidance.

The lack of reliable information also works to the disadvantage of farmers. Wheat prices are usually at their low for the year at harvest time. Farmers that have no place to store their grain, and need cash from the sale of the crop, often take whatever price is offered. Reliable public forecasts of production could help to stabilize prices around harvest time.

It was in this context that the study to evaluate existing forecasting practices and recommend alternative methods was undertaken.

1.1.1 Relative Importance of Wheat to the Egyptian Economy

Wheat has been considered the first strategic food crop for more than 7000 years in Egypt. It has maintained its position during that time as the basic staple food in urban areas, and mixed with maize, in rural areas for bread making.

In general, over 30 percent of the caloric intake is from wheat flour products, primarily bread. The Government of Egypt has subsidized bread consumption for decades as a way to raise nutritional levels and to benefit low-income families. In addition, wheat straw is an important fodder.

Wheat yields have tended to increase gradually over the past five decades. Wheat production increased from 1.3 million tons in 1950 to 1.9 million tons in 1980. However, the production was far below what was needed to meet the demands of the growing population. The annual per capita consumption of wheat has been estimated at about 200 kilograms. The population growth rate of

2.9 % annually, between 1965 and 1980, and 2.6% in the decade of the 1980's, was not matched by similar increases in wheat production. This resulted in a three-fold increase in wheat imports from the mid-1970s. Therefore, increasing wheat production has become an important national goal to reduce the amount of wheat imports, save foreign currency, and provide enough food to meet increasing domestic demand. To address these challenges, a vigorous research program was started to improve genetic potential, develop new production systems, and introduce wheat to new reclaimed areas.

Drastic changes have occurred in wheat cultivation during the past 20 years. Large increases in grain yield per unit area and total production have been realized since 1987. Area under wheat increased from 600,000 hectares in 1987 to 1.0 million hectares in 1999. In the old lands, the average grain yield increased from 4.6 T/Ha in 1987 to 6.8 T/Ha in 1999. As a result, total production in the old lands reached 5.6 million tons in 1999 compared with 2.8 million tons in 1987.

Since 1990, wheat cultivation was introduced to the newly reclaimed desert lands. Its area reached over 150,000 Ha in1998, producing 653,000 tons, with a yield average of 4.2 T/Ha. In 1999, the average grain yield reached 5.3 T/Ha. These efforts increased the total area under wheat to about one million hectares in 1999 and the national yield averaged 6.3 T/Ha, resulting in total production of 6.3 million tons.

The results of these changes were declines in wheat imports from 7.2 million tons in 1987 to 6.6 million tons in 1990, and to 6.0 million tons in 1999 despite the growing population that increased by about 18 million from 1980 to 1999. (See annex B for a time series of wheat area, yield and production for 1981–99 in the old lands, and 1990–99 in the new lands, respectively.)

1.1.2 Importance of Wheat Forecasting to Egypt

There are several reasons why forecasting wheat yield and production are very important to Egypt:

- The GOE operates a major program to produce and distribute subsidized *baladi* bread and flour. It buys wheat from farmers, and also imports large amounts of wheat from abroad. Thus the GOE could benefit from early information on production that could be used in estimating both its procurement quantity and its import requirements.

- There may be some price cycles in world markets. Having estimated production and its import requirements, the GOE might be able to take advantage of lower import prices at certain times of the year.

- Large commercial wheat millers and wheat importers have a major interest in information on wheat production. While they are not allowed to purchase domestically produced wheat, the amounts produced by farmers and bought by the Government will influence the amount to be imported by the private sector.

- Small wheat traders and grinders purchase wheat from farmers. These individuals also have a strong interest in knowing how much wheat is likely to be produced. Many small traders trade a variety of commodities, changing their operations depending on the supply and demand conditions for each commodity. Early information about wheat production will allow them to focus on those commodities where their services are most needed.

1.2 History of Wheat Forecasting in Egypt

Wheat objective yield surveys for early season forecasting started in Egypt in 1985 with USAID's ADCAP funding for three years. The work started in Fayoum in 1985. Sharkia and Sohag were added in 1986; and Dakahlia, Kafr El Sheikh and Assiut were added in 1987. Nothing was done in any of the governorates in 1988. An attempt was made to restart the work in 1989 for one year and then activities ceased until 1993 when it was restarted under a modified program for research purposes. All forecasting activities ended in 1998.

No records of any forecasting work were available except in Fayoum and the AERI. The Fayoum Sampling Office has a complete set of the survey forms and data summaries for 1985 and 1986. A summary of the AERI research studies for 1993 - 1998 was available to the study team and is shown as in annex E.

1.3 Objectives of the Study

The main objectives of the study were to:

- Assess the quality of wheat yield estimates and forecasts being made in the MALR, and
- Recommend the appropriate method to be adopted by the MALR.

Tasks to be accomplished were to:

- Assess the quality of short-term wheat forecasting through:
- Review of relevant documents
- Discussions with MALR staff, and
- Field trips to investigate data collection methods, equipment and materials.
- Design and apply an improved forecasting method and compare the results with the MALR crop cutting results.
- Recommend improvements in the methods used, including data requirements.
- Provide on the job training to MALR staff on implementing and operating the improved methods.

1.4 Outline of the Study

The remainder of this report is divided into six additional chapters plus an Annex. Chapter two overviews the objectives yield forecasting technique and the main components of wheat yield. Chapter three covers the methodology used and outlines the implementation for the study. The major activities and the forecast models are described. Chapter four reviews crop forecasting and estimating in Egypt, including earlier attempts to introduce objective yield procedures for pre-harvest forecasting. It includes a brief summary of the major activities and outputs, and an assessment of each function.

Chapter five is an assessment of the methods proposed and tested in this study. Chapter six outlines the proposed changes to the existing system for crop forecasting. It lays out the structure, resource requirements, and training needed to successfully implement the new program. Chapter seven summarizes the main findings and recommendations of the study; several recommendations for follow-on studies are also included.

2. OBJECTIVE YIELD FORECASTING FOR WHEAT

Objective surveys have been the predominate methodology for forecasting major crop yields in the United States for nearly 50 years, and have been introduced into several other countries during that time. General experience and research indicated that objective surveys for yield forecasting might be suited to conditions in Egypt.

2.1 Overview of the Forecasting Technique

Work in the mid-1980s, and research since that time, indicated that reliable and useful pre-harvest forecasts of wheat yield could be generated from a relatively small sample of plots laid out in wheat fields early in the season. During scheduled periodic revisits until harvest, researchers gather specified measurements and counts from plants and fruit in the sample plots. Data from each visit are used in forecasting models to project final components of yield based on the current counts and measurements.

Methodology that is successfully used in other countries was adapted to conditions in Egypt. The basic concepts of objective yield pre-harvest yield forecasting have not changed since the method was introduced in the United States in the early 1950s, but sampling techniques and field procedures are constantly being refined. Consequently, this study is similar to the 1985 project in many ways and includes some improvements in sampling, training and field procedures.

2.2 Components of Yield

The combined effect of the number of heads, number of grains per head, and weight per grain determines wheat yield. These factors are the focus of plant breeders as they strive to produce higher yielding varieties. The same three characteristics are the main items of interest to statisticians in their work of forecasting yield.

2.2.1 Agronomic Perspective

Total yield of wheat per feddan is the combined effect of (1) number of fertile spikes per feddan, (2) number of kernels per spike, and (3) weight of kernels, on the so called “yield-triangle.”

The number of spikes per feddan is considered the main contributor to the obtained grain yield, and is affected heavily by cultural practices and how the crop is managed. This production factor exceeds the combined effect of the other two production factors, i.e. number of kernels per spike and kernel weight. Under Egypt’s conditions, the number of spikes ranges between 300-700/M^2 with a national average of 400 spike/M^2. The yield average is 17.8 Ardab/feddan (6.3 T/Ha) in the old lands, and ranges from 12 - 28 Ardab/feddan (4.5 – 10.5 T/Ha).

Number of kernels per spike of the currently grown cultivars averages 60 kernels/spike in the normal spikes cultivars, and 100 kernels per spike in the long spike cultivars. The 1000 kernel weight ranges between 38 grams up to 72 grams in some long spike cultivars.

Each cultivar of wheat has a genetically determined yield potential, but environment determines how closely actual yield approaches genetic potential. It is fairly certain that the full yield potential is never achieved under field conditions, because at some time during the growing season one or more of the environmental factors is limiting. Moreover, any production factors which limits the maximum contribution of any one or more of the yield triangle sides results in decreased yields. The national wheat yield average is relatively high inspite of a 20% gap between actual yield as compared to potential yield. Management, lack of extension, small farm size, and poor cultural practices contribute to the difference.

The modern high yielding varieties have been widely adopted in about 80% of the wheat growing area. Farmers also take advantage of more efficient fertilizer use, better tillage techniques, more appropriate crop rotation, adequate stand establishment, and weed and aphids control. Land preparation with tractors, using drills, and mechanical threshing have also been widely adopted.

Sowing date is one of the most important factors influencing maximum grain yield. Planting through November does not affect the yield negatively in most Egyptian regions. Early November planting is optimum for Upper Egypt, while planting around mid November is optimum for the Delta and Middle Egypt.

A slight increase in grain yield can be achieved by increasing seeding rates. The optimum seeding rates for dry and wet planting is150 and 180 Kg/Ha, respectively. However, drilling grain into well-prepared soil decreases the optimum seeding rate to 110 Kg/Ha. Chisel plowing, disc harrowing, and dry-leveling produces maximum grain yields. Laser-leveling increases yield with all planting methods.

Increasing nitrogen N level up to 250 Kg/Ha produces the highest grain yield under heat stress conditions in the new lands through Upper Egypt. In the old lands, the highest economic grain yield can be obtained by applying 180 Kg N/Ha and P_2O_5 at the rate of 35 Kg/Ha. Nitrogen application should be split between the first irrigation (tillering stage) and the second irrigation (starting of stem elongation stage). Early application at planting time is not necessary. However, the early dose could be important for low fertility soils. Phosphorus should be incorporated to the soil before planting.

Using five and six irrigations for wheat fields boosts grain yields by about 21 - 35 %. Two irrigations before stem elongation increases grain yield by 11 - 22 %.

2.2.2 Statistical Perspective

Independent mathematical models can be used to forecast the three components of yield; number of heads, number of grains per head and weight per grain. The head count model uses the number of stalks, the number of late boot heads and the number of emerged heads to forecast heads that will reach maturity. The number of fertile spikelets and grains per spikelet are used to forecast the number of grains per head. Weight per grain is based on the historic average until the plots are harvested and current year grain weight is available. Although the accuracy of the models increases as plant development moves closer to harvest, forecasting can start very early in the season based only on the number of stalks.

2.3 Statistical Models for Forecasting

The forecasting models have the following form:

$Y_i = a + b X_i + e_i$

Where

Y_i = number of heads or weight per head.
a = number of heads or weight per head when X equals zero,
b = the change in number of heads or weight/head for each unit increase in X,
X_i = the independent variable from current field counts or laboratory measurements: number of stalks, number of emerged heads, number of late boot heads, number of fertile spikelets/head, grains/heads or weight/head.
e_i = errors

Gross Yield (GY)

GY = Y_h * Y_w * conversion factor

Where

Y_h is the forecast number of heads.
Y_w is the forecast kernel weight per head.

Final Weight Per Head Y_{fw} at 12.5% moisture

$$Y_{fw} = \frac{\text{(Threshed kernel wt)*(1.0-kernel moisture content)}}{\text{(Number of heads threshed) * (0.875)}}$$

2.4 Data Requirements for Modeling

Data needed for the mathematical models come from a combination of current and historic sources. The only current data available early in the season is the number of stalks, and the models draw heavily on historic databases. More of the historic data is replaced with current year counts and measurements as the crop develops toward maturity. Final yield is computed using only current data when the field is mature and the plots are harvested, Table 2-1.

2.4.1 Current Data

Counts and measurements from the field plots and laboratory analysis provide the current data needed. The number of stalks in the sample plot is the only observable characteristic early in the season when plants are in the vegetative growth stag. Historic data is replaced by current counts and measurements as the crop moves toward maturity. The plots are harvested and final yield is computed using only current year counts and measurements when the plants are mature.

Other observations, counts and measurements are made during the field visits to gather information useful in reviewing and analyzing the plot data.

2.4.2 Historic Data

Two major pieces of information used in early season forecasts must come from historic databases. The number of heads at maturity is forecasted using (Preflag and flag or early boot maturity stage) plant survival ratios computed from historic survey data. Survival ratios are computed by dividing the number of heads at maturity by the number of stalks at various early stages of maturity. The weight of grain per head can be determined only after the plants are harvested. Therefore, the number of grains per head is forecasted using number of fertile spikelets and number of grains per spikelet. Historic average grain weight is used until the sample plots are harvested and the grain weighed. At least three years, and preferably five years, of survey data are needed to compute stable average survival ratios and average weight per grain.

2.5 Types of Error

Some level of error is inherent in any human process. Two major types of error affect data gathering and impact survey results. Controlling both sampling error and non-sampling error should be a prime consideration when designing and conducting surveys.

2.5.1 Sampling Error

Sampling error occurs when samples are used instead of complete enumeration to collect data. Sampling error results from the variability among the sample units at each stage of sampling and is inherent in the process, but can be measured, and controlled to a certain extent. By analyzing the variance in sample data, a statement can be made about the precision of the estimate and confidence limits placed on the estimate.

2.5.2 Non-Sampling Error

Non-sampling error is the result of inconsistencies in procedural operations. Some level of non-sampling error is always present but cannot be quantified. Unintentional mistakes in measuring, counting, calculating and recording are a few of the sources of non-sampling error. Survey results can also be altered by intentionally changing data or the processing procedures to bias the results in a certain direction. Recognizing that non-sampling error is always present, establishing strict quality control procedures, and increasing training of survey staff and education of data users, are the best ways to improve data quality.

Accuracy is very important. In the relatively small (2m x 2m) wheat crop cutting plot, the loss, or erroneous inclusion, of one head represents 1050 other heads, (2.1 kg.) at the feddan level. The loss of 71 heads would reduce computed yield by one ardab/feddan.

Table 2-1: Summary of Existing Statistical Models for Yield Forecasting and Their Requirements

Maturity Stages	Final Number of Heads		Final Weight of Heads	
	Model	Independent Variable	Model	Independent Variable
1) Pre-flag 2) Flag or Early Boot	1	Number of Stalks	1	Historical Average
3) Late Boot, Emerged Heads, Flowering	1 2	Number of Stalks Emerged Heads + Heads in Late Boot	1 2	Historical Average Fertile Spikelets per Head
(4) Milk	1	Emerged Heads + Heads in Late Boot	1 2	Grains per Head Clip Unit Green Weight per Head
(5) Soft Dough	1	Emerged Heads + Heads in Late Boot	1 2	Grains per Head Clip Unit Green Weight per Hear
(6) Hard Dough (7) Ripe		Actual Count of Emerged Heads, Detached Heads		Actual Threshed Weight per Head Adjusted to Standard Moisture (12.5%) Determined from the Laboratory Work

2.6 Other Measurements and Observations

Information on some other factors correlated with yield was collected from the sample fields. Observations about conditions in the field were also recorded. The measurements of plant characteristics are intended for use in research to improve and refine the forecasting models. The information about field conditions should be helpful in reviewing and analyzing the survey data.

2.6.1 Main Characteristics Associated With Yield

Many plant characteristics are known to be correlated with final yield. However, factors that are useful for forecasting must exhibit this relationship in the immature stages. The wheat researches identified the following characteristics as potential indicators of one or more of the components of yield. If any of these simple factors prove to be a reliable and stable indicator of one of the components of yield, it could streamline the forecasting process. Several years' data will be needed to determine if any of the factors are useful indicators of final yield.

- **Plant height -** agronomists use plant height as an indication of head weight. Measurements of the height of plants from the ground to the top of the head, excluding the awns were taken at several places near the plot and the average recorded.

- **Flag Leaf Area -** the width of flag leaves, at the widest point, and the length of the flag leafs, from the main stem to its tip, were measured on several plants and the averages recorded. Flag leaf area is thought to be correlated with head weight.

- **Dry Weight of Plants -** this is another factor that agronomists have associated with final head weight. In Assiut only, five plants were harvested form outside the plot by clipping the stems 5 cm above the ground. The plants were weighed in the laboratory and the heads removed and weighed separately. The heads and plants were then dried and weighed again.

2.6.2 Factors Affecting Productivity

The enumerators gathered information about factors that affect productivity through observation and farmer opinion. Observations on the level of irrigation; pest infestations, disease and predator damage; and lodging were recorded from observations. The farmers reported fertilizer and pesticide usage, source of planting seed and seeding rate, expected dates of future irrigation and expected date of harvest. This information will give the office staff information to use as they review the field data reported by enumerators and analyze the summary data.

3. STUDY PLAN AND IMPLEMENTATION

Both published and unpublished documents were useful in reviewing and assessing the current forecasting and estimating program, and formulating a recommended method to be adopted by the MALR. The team drew heavily from a previous MVE publication (Morsy et al., 1998) on agricultural data quality. This was the principal document used in assessing the status of crop estimating. It was also useful in defining the recommended changes to the existing program. Another recent MVE study on Cotton Forecasting provided useful ideas in designing and implementing the study.

Instruction manuals and reporting forms used in the 1985-87 ADCAP were helpful in designing forms for the study. The forecast models, field practices, and data review and analysis procedures were adapted from USDA/NASS wheat objective operation manuals. AERI unpublished research reports provide valuable information on head weight and survival ratios for developing and testing the statistical models used in the study.

Much valuable background information about wheat production in Egypt and the importance of wheat to the country came from various MALR publications, including those by ARC and EAS.

3.1 Implementation of Assessment by MVE Team

The following are the tasks undertaken by the MVE team:

- Selection of a team comprised of MALR, ARC, university, expatriate and MVE staff experts.
- Establishment of the goals for forecasting wheat yield.
- Review of all past reports, instructions, manuals, models, and data.
- Review of information about forecasting procedures used in other countries.
- Review of past models used in Egypt and potential models used elsewhere.
- Review of all available data and how they were used to make forecasts.

  The team reviewed all materials that they could find related to the procedures used in the past by Egyptian agencies. Also a review was made of materials from external sources regarding techniques used in other countries to forecast or estimate crop production. An analysis of the materials obtained was done to determine the quality, strengths and weaknesses of past procedures in order to help the team plan their work and discover improved ways to forecast crop yield and production.

- Visits and interviews in national, governorate, and district offices.

  Prior to selecting the seven study sites the team visited the suggested six governorates and Nubaria region with MALR personnel at the national levels. At each of the study site the team interviewed the governorate leaders, especially the governorate sampling office heads and local officials were interviewed when appropriate. In districts they worked with the field staff and often had chances to interact with local officials who stopped by to learn what the teams were doing. The team asked the officials about the past and present procedures, their opinion about the accuracy of the methods, their problems and constraints in doing their work, their training level and what they felt was needed to improve the forecasts. The results of the discussions were useful in the team assessment of current procedures and in designing the study. The detail of these discussions can be found in annex A. Also a listing of most of those persons visited or with whom the team worked is in annex A. Nearly 100 persons were contacted by the team.

- Observation of current fieldwork, documents and estimation process.

- Field observations of current procedures in crop cutting and forecasting plots

  The team felt that actual observation of the sampling procedures, data gathering methods and forecasting methods was critical to their assessment and recommendations for improvements. During interviews with officials they heard how the work was being done, theoretically. As they asked further detailed questions, they found that the actual methods were often different. Likewise, as they observed the work being done in the field, they saw methods used that were reducing the precision of the results. These practices were being done without the staff realizing the negative effects. The team helped correct some of these improper procedures during the initial visits and designed forms for recording the data for all subsequent visits. These improvements undoubtedly helped this year's forecasting to be more precise.

  Field procedures are critical to the estimation or forecasting process. The most sophisticated model or method for forecasting is of little value if the data put into the process are not reasonably precise and derived in the expected manner. When one considers that each plant or fruit in the sample plot (60 cm x 60 cm) represents 1050 others in a feddan, it becomes clear that accuracy in laying out the plot and making counts is very important. The importance of just one plant or fruit is often overlooked by the enumerator when counting in the field on a hot day. Thus it was important for the team researchers to observe just how the data were being gathered

- Testing of new procedures and forms

  The team has found that it is always important to suggest and test new procedures while the work is under way. During the gathering process, other questions arise which, when answered, give further insights into the process. Ideas for improvement are generated. When questions about the data arise during the assessment process, those involved in the data gathering process can better understand what is taking place.

  While in the field the team members can devise better methods, procedures and forms for future improvements to the MALR staff. These can also be tested under field conditions to determine how well they will work.

Listed below are some of the observations and ideas team members got from their visits to governorates officers and participating in the field work during the study.

< Assessment of past and present procedures to determine those that might be used in the future.

< Assessment of how well the sample represents the wheat population.

< Identification of plant growth characteristics; how they vary by variety or location.

< Determination of how plant characteristics can be used to forecast yield.

< Analysis of past forecasts relative to other estimates and information.

< Recommendations of models for future forecasting work along with a schedule of implementation.

< Recommendations for improved sampling procedures.

< Recommendations of improvements to survey procedures and forms.

< Recommendations of procedures and models that should provide accurate, timely, cost effective forecasts and be manageable. If possible include an estimate of manpower, equipment and budget requirements.

The study was designed and carried out by the study team and the EAS to test the method and demonstrate its operational procedures. Four pre-harvest visits and the harvest visit were scheduled to the sample field. The timing, maturity stage of plants, field activities and information gathered on each visit are summarized below. See annex D for data collection and laboratory forms.

- First visit - late January when plants were in the pre-flag stage, maturity stage one. The plots are laid out in the sample fields, and the number of stalks (tillers) are counted in the count area. The sample plot includes two adjacent 60cm x 60cm sections -- a count area and a clip area. The count area is used for counting stalks, late boot heads and emerged heads on each monthly visit, and is harvested for final yield determination when the plants are mature. The area is divided into quadrants for ease of counting. The clip area is divided into six 30cm x 20cm blocks. Plants from one designated block are harvested on each visit for laboratory analysis. Attachment defines the various maturity stages used to structure the forecasting models.

- Second visit - late February, most fields are in flag or early boot, maturity stage two; or late boot and flower, maturity stage three. Total stalks, number of late boot heads, and number of emerged heads are counted in the count area. Plants in clip area number one are counted, and the late boot and emerged heads harvested and sent to the laboratory for analysis.

- Third visit - late March, essentially all heads are emerged and most fields are in milk, maturity stage four; or soft dough, maturity stage five. Total number of stalks, number of late boot heads, and number of emerged heads are counted in the count area. Clip area two is harvested and the plants sent to the laboratory.

- Fourth visit - by the late April visit over 80% of the fields were in hard dough, maturity stage six; or ripe, maturity stage seven. The remaining plots were still in maturity stage five. The third visit counts and activities are repeated for the fields still in maturity stage five and clip area three is harvested for laboratory analysis. Plants in the count area are harvested, counted and the heads sent to the laboratory for final yield determination for fields in maturity stages six and seven.

- Harvest visit - fields still in maturity stage five on the fourth visit are closely monitored, and the enumerators return to harvest the plots when the fields reach maturity stage six.

- In addition, observations and measurement were made for some plant characteristics thought to be correlated with yield. This information will be used in research to explore refinements in the forecasting models. The additional information collected is covered in Section 4.1.

3.2 Sampling and Study Sites

The sample for the study was selected using a modified multistage probability sampling approach**.** It was not an objective of the study to produce survey results that are completely random and statistically defensible. On the other hand, including areas that are representative of the major wheat-growing areas and grow the principal varieties was an important consideration. With these interests in mind, two districts were pre-selected within each governorate. The sampling scheme within district includes two clusters (exceptions, one cluster was selected in Noubaria and three clusters in Assiut), two fields within each cluster, and two plots within each field. A third cluster was added in Assiut to include durum varieties. This is an efficient sampling plan and provides the survey data needed to compute the components of variance at all levels of the sample. The sample included 112 plots in 56 fields (See Table 3-1).

The study included six governorates, plus Noubaria. These governorates represent the major geographic regions of Egypt, and grow the three major genotypes and varieties of wheat. Kafr El Sheikh and Sharkia, represent the Lower and Upper Delta, respectively. Gharbia and Beheira are in the Middle Delta. Much of the newly reclaimed land is in Noubaria where limited yield work and no crop forecasting is done. Both medium-spike and long-spike bread wheat is grown in these governorates. Fayoum geographically represents Middle Egypt and has a large area under wheat. The sampling office staff has carryover experience from the 1985-86 forecasting project. Geographically, Assiut is in Upper Egypt and includes about 8,000 acres of reclaimed land that is not included in any current surveys. In addition, some durum wheat is produced in the governorate.

Agricultural research stations are located in Kafr El Sheikh, Gharbia, Noubaria, and Assiut. The research stations offer many advantages to the study. One of the great needs for training is in the area of agronomic characteristics of the wheat plant. Agronomists at the research stations are a rich resource to provide this training. Establishing communications with the stations can open a channel for ongoing training of agricultural engineers in basic plant physiology. The two agencies working together will increase the efficiency of government. And finally, the research stations have facilities that can be used to train large groups of people.

Laboratories were set up in Gharbia and Assuit for processing the field samples. The Gharbia lab processed samples from all Delta governorates and Noubaria, and samples from Fayoum and Assiut went to the Assiut lab.

Table 3-1: Sample Size and Area Planted for some Governorates, Year 2000

Governorate	District	Variety	*Area Feddan	Number of Clusters (PSUs)**	Number of Fields	Number of Plots (60cm X 60cm)
Beheira	**Delengat**	**S69,,61,,8**	**26,707**	**2**	**4**	**8**
	Damanhour	**S 69**	**26,210**	**2**	**4**	**8**
	Gv. Total		**235,697**	**4**	**8**	**16**
Noubaria	**Sugar Beet**	**S8**	**45,223**	**1**	**2**	**4**
	Busttan	**S69**	**22,185**	**1**	**2**	**4**
	Total		**67,408**	**2**	**4**	**8**
Gharbia	**Zefta**	**S69,,61**	**16,575**	**2**	**4**	**8**
	Tanta	**S69,,61**	**20,953**	**2**	**4**	**8**
	Gv. Total		**135,102**	**4**	**8**	**16**
Kafr El-Sheikh	**Sidi Salem**	**S61,,69,,8**	**23,158**	**2**	**4**	**8**
	Kafr EL-Sheikh	**S61,,69,,8**	**29,372**	**2**	**4**	**8**
	Gv. Total		**185,703**	**4**	**8**	**16**
Sharkia	**Dyarb Nigm**	**S69**	**16,887**	**2**	**4**	**8**
	Zagazig	**S69**	**29,801**	**2**	**4**	**8**
	Gv. Total		**307,000**	**4**	**8**	**16**
Fayoum	**Etssa**	**S69**	**43,187**	**2**	**4**	**8**
	Fayoum	**S69**	**27,753**	**2**	**4**	**8**
	Gv. Total		**148,899**	**4**	**8**	**16**
Assuit	**Assuit**	**S69,G164 ,Durum**	**18,145**	**3**	**6**	**12**
	Dyrout	**S69,G164**	**18,205**	**3**	**6**	**12**
	Gv. Total		**135,407**	**6**	**12**	**24**
Total	**Sample Districts Governorates**			**28**	**56**	**112**

* Preliminary wheat crop area.
* Feddan = 4200 m^2
** Primary sampling unit (PSU) = cluster about 200 Feddan cultivated area.
S= Sakha G= Giza
Source: Wheat Yield Forecasting Study, MVE Unit, APRP, 2000.

3.3 Modifications to Models for the Study

A full range of application of the models was not possible because databases of previous survey results are not available. Alternative historic data sources were used for development and preliminary testing. Final testing and application used only the final results of the study field plots. Any pre-harvest forecasts computed on an empirical basis using only final data from the sample plots would produce results identical to the final yield computation.

3.3.1 Plant Survival Ratios

Survival ratios, computed by dividing the final number of heads at harvest by the total number of stalks from the various pre-harvest counts, are the core of the model for forecasting the final number of heads. Three to five years of survey results are needed to compute survival ratios. The survival ratios for the study could be computed only after the plots were harvested. Several years of research results from AERI studies were useful for development and early testing. This information also served as a guideline for evaluating survival ratios computed from the study's survey results.

3.3.2 Kernels Per Head

Final number of spikelets and kernels per spikelet were used in combination with the final number of kernels per spikelet to develop, test and apply this model. ARC research data provided guidelines for testing and evaluating the kernel count model.

3.3.3 Kernel Weight

Information from the AERI studies, shown in annex E, and from the ARC breeding and variety testing programs, provided indications of average weight of grain per head. As in the above cases, final application used only the field and laboratory results of the study.

4. ASSESSMENT OF EXISTING FORECASTING PROCEDURES

The study team visited Nobaria and six governorate sampling offices, Kafr El Sheikh, Gharbia, Behira, Fayoum, Beni Suef, and Assiut during the study period (November 1999-May 2000) to assess wheat yield estimating and forecasting procedures. Sampling office officials were asked to comment on current activities including: survey activities, procedures, training, and cooperation with other government offices, resource needs and level of support. Others interviewed included farmers, extension agents and the director of a cooperative. The assessments in this chapter are based on documents from previous studies, interviews, opinions, observations and institutional knowledge. MVE's previous study on data quality and availability (Morsy et al., 1998) was especially valuable and provided much useful information for the analysis. That study describes MALR's data collection procedures in detail and provides some evaluation and recommendations for improvements. This chapter gives a brief summary of the major surveying procedures and outputs, and analyzes and assesses each function. Recommendations for changes to improve the present system are covered in Chapter 6.

4.1 MALR Staff Role

4.1.1 Description

The MALR, EAS, through its CAAE, has responsibility for collecting and publishing statistics on wheat area, yield and production. Surveys to determine area under wheat are carried out at the village level through the agricultural extension agents**.** In addition to data collected through its own facilities, EAS uses area data gathered by the ESA, MPWWR in determining the official estimate of area under wheat.

Sampling offices in each governorate, with branch offices in some districts, conduct crop-cutting surveys to determine wheat yield. Governorate sampling office staffs do and supervise the fieldwork.

GOE production and yield targets are less common than in the past as the agricultural sector becomes increasingly privatized. However, governorate officials are sometimes rewarded for improving crop yields in their governorate or for achieving a target level.

4.1.2 Assessment

Governorate office staffs are commended for the work they do under very difficult conditions. The demand for statistics on agriculture continues to increase as the sector becomes more privatized, while the facilities and resources to provide more and better statistics lag farther behind the demand. Staff is generally under trained and poorly equipped technically to carry out the jobs they are asked to do. A request for training in applied agricultural statistics, survey procedures and plant characteristics was expressed at every sampling office visited by the team. The MALR does not have a program for in-service training for agricultural engineers at the governorate level. Many engineers with long service records have received little or no training in sampling and survey methodology and survey operation to build technical skills. There is also a lack of understanding of the importance of accuracy and the implications of errors. The prevailing attitude is to produce numbers with little concern for accuracy. Some training, mostly of a specialized nature, has been provided for special survey work MALR takes on from time to time. Such training is helpful, but falls far short of what is needed to equip the field staff with the expertise they need to do consistent, high-quality work.

New engineers are often brought on board and expected to immediately begin performing their assignments at a high level of proficiency without any introductory training. New engineers are usually paired with an experienced employee in order to gain on-the-job training. This is a sound concept, but its effectiveness is limited by the low expertise level of the existing engineers. Experienced engineers, even though sincere in their efforts to help new engineers learn their jobs, may unintentionally pass along poor work habits and erroneous procedural instructions.

Rewarding officials for improving yields, or achieving target yields, is a disincentive for accuracy. It has the potential to introduce an upward bias into the yield estimate.

4.2 Sampling Technique

4.2.1 Description

The sampling procedures used for selecting area and crop-cutting survey samples are statistically sound. However, a thorough review of the sampling frame and the sample size likely would reveal some inconsistencies and inefficiencies. This section describes the procedures used to select the crop-cutting sample.

The total production of wheat is the product of two components, the yield per feddan, and the area under wheat. Both must be determined with accuracy and without bias each season to provide reliable estimates of production. The yield can be accurately determined by conducting crop-cutting experiments in randomly selected plots of prescribed dimensions. Yields determined by this method are relatively free from human biases, and provide reliable and stable results. A statistically valid sampling scheme, and clearly defined and consistently applied survey procedures, is necessary for successful operation of this methodology.

A stratified multistage sampling design is used to select the crop-cutting survey sample. Estimates of the yield per feddan and total production of wheat are needed with high precision at the governorate level for agricultural development planning and economic purposes. Therefore, each governorate is a domain or tract under study. Within each governorate, the sample is allocated at the district level. The cultivated land within a district is stratified according to fertility and type of underground tube drainage by hode. Within each stratum, a certain number of sampling units or plots are selected in four stages.

The agricultural land is cadastrally surveyed and divided into governorates (Mohafazat), governorates into districts (Marakez), districts into villages, and villages into hodes. The size of a village is usually too large to adopt as a cluster or PSU. On the other hand, hodes, which averages about 100 feddans in size, are inappropriate for forming clusters. The target size of clusters is about 200 feddans of cultivated land, but range in size from150 to 250 feddans. Combining a number of hodes within the same stratum forms clusters. The crop cutting plots are located in these clusters by three additional stages of sampling. The same frame of clusters is used for different seasonal crops throughout the year. For each crop, the appropriate number of clusters is selected, depending upon the precision required in the final estimates. For maximum economy of fieldwork and supervision, it is desirable that the same PSUs be used for crop cutting surveys for all crops in a season. Separate strata can be formed and the appropriate number of clusters selected for crop that are grown in concentration in a few villages.

Within each selected cluster, two parcels growing wheat are randomly selected out of all parcels growing the crop. This constitutes the second stage of sampling. One wheat field is randomly selected from all of the wheat fields in the parcel. This is the third stage of sampling. The final stage consists of selecting a pair of random numbers from a random numbers table for locating the plot of prescribed dimensions (2m x 2m), within the selected field. The wheat plants within the experimental plot are harvested and weighed in accordance with the instructions. The plots should be harvested on the same day as the sample field, and to the extent possible, using the usual methods followed by the cultivators.

The sampling frames vary by governorate. In Beheira, Ministry of Irrigation maps showing area by hode are used. A hode by hode listing of cultivated and non-cultivated areas taken from the Ministry of Security Record Number 15 is used in Assiut. Other governorates may use a variation of one of these, or something entirely different. Cadestral maps are available in local agricultural cooperative offices for most villages**.**

The DOS headquarter office determines the optimum sample size for each governorate based on the analysis of the previous year's data, and allocates the sample at the district level.

After receiving the sample size from headquarters, the governorate sampling office staff proceeds with selecting the sample. A stratified multistage sampling procedure is used for sample selection in each governorate. Cultivated land area is classified into strata based on the type of irrigation and age of tile drainage**.** Similar land areas are grouped into clusters. Theoretically, clusters are about 200 feddans in size. In reality, however, the cluster size varies depending on the governorate. In Beheira the cluster size is 150 - 200 feddans, Dakahlia about 200 - 250 feddans and about 300 - 350 feddans in Assiut. Area under wheat in the selected cluster is listed by field and summarized.

Sampling units about three feddans in size are formed in the selected cluster. If a prospective sampling unit exceeds five or six feddans, it is divided into three sub-units and one of the divisions is selected to represent the area. Two sampling units are randomly selected from each cluster, Table 3.1.

4.2.2 Assessment

The sampling frame materials are outdated and in varied and, often, inconvenient scales. Names of villages and uses and characteristics of land have changed. Sampling offices do the best job possible to maintain sampling frames, but the frames continue to deteriorate.

Some governorates are developing the skills to analyze survey data, compute variances and determine sample sizes. A lack of training and computers hinder the growth of this capability.

Stratification based on type of tile drainage has likely lost its effectiveness. Underground drainage systems installed many years ago have deteriorated due to the lack of maintenance. Furthermore, the large number of strata increases the total sample size.

Having access to the village cadastral maps would be helpful to sampling office staff in several ways, but the low level of cooperation with local extension agents restricts access to the maps.

4.3 Area Estimates

4.3.1 Description

Two methods of estimating area under wheat are used. The first method is a complete enumeration of all wheat fields by the extension agents at the village level. Village totals are passed to the agricultural cooperative directors who supervise three to six extension agents. Cooperative directors send the data to the district statistics offices. District data are accumulated in the governorate statistics offices and finally sent to the MALR, EAS headquarters office in Cairo.

The second survey is conducted by the ESA, MPWWR using a sample of area clusters (hodes) provided by the MALR, EAS, and DOS. In theory, 50% of the wheat area in each district is measured each year by the ESA staff. It is difficult to determine what percentage of the fields are actually measured before the data are plotted on 1/2500 scale maps that are sent to Cairo. Twenty-five percent of the fields are supposed to be re-measured by the supervisors for quality control. Although this survey is said to be independent of government influence, much of the fieldwork is done in cooperation with the extension agents who do the field enumeration for the MALR survey.

The ESA sample for area estimation is fixed for five years, while the MALR sample is redrawn every year.

4.3.2 Assessment

Both of these methods have some positive attributes. The extension agents are in the best position to have knowledge about area under wheat. Therefore, the village level data have the potential to be very accurate. The ESA survey is independent of MALR and has the potential to be relatively free of political influence. If the stated sampling fraction (50%) is achieved, the survey results should be fairly accurate.

Frequent, and sometimes large, changes are made in the village and district estimates as they move to higher levels. Area, yield and production estimates, for Damanhour, Kom Hamada and Hosh Eissa districts in Beheira governorate for 1992-97, illustrate the level of the changes that sometimes occur. Comparisons of the average district estimates with the average published estimates for these six years show that the published yield was almost always higher.

Both methods are lengthy and labor-intensive processes. There is no preset date for the public release of the official estimate, and it is usually not available until April or May. Differences in the results of the two surveys sometimes have to be resolved and may result in changes to some of the governorate estimates. Resolving differences adds to the processing time and further delays release of the official estimate. Some of the difference in the two estimates may be due to the different sampling methods. Estimates are not available when needed to select the sample for crop forecasting surveys as proposed in Chapter 6.

4.4 Yield Estimates

4.4.1 Description

One official estimate of wheat yield is made each year and is based on crop cutting surveys. Crop cutting has been the predominate method used for estimating wheat yield since 1956. Farmers are notified directly by the governorate sampling office, or through the extension agents, that their field has been selected for the crop cutting survey. The farmers are asked to delay harvest until the sampling office staff arrives.

The 2m x 2m plot is established in the sample field and harvested by, or with the assistance of, the farmer and the grain is weighed. Using the plot grain weight, average yield per feddan is computed for each plot. Yield for the district is computed by weighting the plot yields by their respective representative area. The production of the district is computed by multiplying the average yield per feddan by the area under wheat. The production of the governorate is the sum of production in its districts.

4.4.2 Assessment

Sample size is unusually large in an attempt to improve survey performance. In 2000, 5,124 wheat fields were selected for crop cutting. This sample size returned survey results with a S.E. of about 0.5% at the national level. Sample size could be reduced by 50% or more and still achieve a S.E. of about 1.0%.

The estimate is not available until several weeks after harvest is finished. Consequently, MALR officials, wheat researchers, and others with knowledge about the wheat industry, are frequently asked for subjective evaluations of the potential crop size. These speculative projections are often misleading and can do more harm than good. There is no substitute for reliable data, and bad data are often worse than no data at all.

Quality control procedures are built into the system, but are not consistently applied. Therefore, the source and level of non-sampling-error is not known.

Responsibility is placed on the farmer to delay harvest of the field until the sampling office staff arrives to harvest the plot. This can be an inconvenience to the farmer as he rushes to harvest his wheat and get another crop planted. All data processing is done by hand and is subject to error. Analysis of the survey data is done at EAS headquarters. Removing the analysis and review function from the local office sacrifices valuable institutional knowledge built up through long-term experience with local conditions. Storing and preserving survey data records is not a priority, and the potential future value of the data is often lost.

Crop cutting produces a biological yield and must be corrected for harvest loss to obtain net yield. Ignoring the effect of grain lost during harvest loss can have a major effect on the accuracy of yield estimates. Procedures for measuring harvest loss are inconsistent. Technical coefficients that have not been tested and updated for many years are used to adjust for harvest loss.

4.5 Yield Forecasting

4.5.1 Description

The only organized attempt to make pre-harvest forecasts for wheat was under the ADCAP in the mid-80s. All activities stemming from the ADCAP were stopped in 1998.

The original sampling plan was to tie the yield forecasting sample selection to the regular crop-cutting sample selection. The sample size was 50% of the crop-cutting sample – one of the two parcels from each cluster selected for crop cutting (see crop cutting sampling plan, section 4.2 and annex B. One field was selected in each parcel and one plot was laid out in each selected field. The total number of samples (optimum sample allocation) was determined by the DOS headquarter office and samples were distributed within districts by the governorate sampling offices.

Governorate sampling offices did the fieldwork. Three pre-harvest field visits were scheduled to the sample field. Sample plots were laid out on the first visit in late February when plants were in the tillering to early boot stages -- maturity stage one or two.

The second visit was in late March when plants were in the late boot and flower stage -- maturity stage three. The third visit was scheduled for late April when most of the wheat was expected to be in the soft dough to hard dough stages (maturity stages five and six). Harvest of the forecast plots was scheduled at the same time the crop-cutting plot was harvested. Since harvest begins in mid-April and peaks during the first week of May, many fields were mature and could have been harvested on the third visit.

Forecasting models similar to those used in the current study were used to forecast the components of yield (Chapter 5). Under the modified program in 1989, the sample size was reduced to five plots per district and only one pre-harvest visit, in mid-March, was scheduled.

4.5.2 Assessment

It is not known if the survey results were ever used to support early season forecasts or final estimates**.**

The work in Fayoum indicated that the methodology introduced in 1985 was appropriate for Egypt, and it could have become a valuable tool for improving wheat forecasts and estimates. The team's visit to the governorate sampling office found complete records of the 1985-86 field work, and the field and laboratory equipment used. Eight of the thirteen agricultural engineers trained in 1985 are still working in the office. A complete set of field equipment and reporting forms were provided under the project. The governorates added in 1986 also received training and support from the project team, but none of the governorates added after 1986 received any training, equipment or other kinds of support from the ADCAP or MALR. This failure to support the work lowered the morale of the field staff and made it difficult for them to do high-quality work.

Although governorate sampling officials spoke of conducting wheat forecasting surveys, no records of any activities were available outside of Fayoum. The local officials complained about the lack of training and support and had to sometimes pay for forms and other survey supplies out of their personal funds.

The work got off to a good start in 1985 and continued to improve in 1986. After 1986, support declined due to budgetary constraints and other problems. The attempt to restart the work in 1989 floundered from a lack of support. The absence of support from the ADCAP and a major reorganization of MALR were major factors that contributed to the work not surviving.

The way ADCAP provided support, especially the manner in which salary incentives were applied, probably contributed to the lack of sustainability of the work. Salary incentives were paid directly from project funds. All employees in the governorate sampling offices that were included in the project, and selected employees in the Cairo MALR offices that administered the project, regardless of whether they were directly involved in the project work, received incentives. The operation of the project was concentrated in a few hands and excluded input from other government offices that could have contributed to its success. As a result, the new work was not institutionalized and accepted as a potential improvement to the existing wheat forecasting and estimating program. This lack of broad-based support was a major factor contributing to its demise during the MALR reorganization.

4.6 Equipment and Support

4.6.1 Description

Field equipment for crop cutting survey work consists of a cross-staff, steel pegs, cords, measuring tape, and scales or balances.

Sampling office staff must have adequate transportation to conduct the fieldwork in a timely manner. Additional cars are sometimes hired during periods of peak workload.

The sampling offices must stay in contact with the farmers to determine when the sample fields will be harvested.

4.6.2 Assessment

The need for more and better equipment was a common request during the team’s visits to sampling offices in the governorates. The equipment in use is old, in poor condition, and some pieces do not function properly. Because of the size and weight of the equipment, transporting it to the field is a problem, particularly, if the enumerator travels by motorcycle.

Few cars and motorcycles are available. Most of the motorcycles are very old and in poor mechanical condition. Some agricultural engineers provide the use of their personal motorcycles. The lack of adequate transportation slows down fieldwork and delays final completion of the survey. This contributes to lost samples due to farmer harvest. If the farmer delays harvest, the condition of wheat plants deteriorates and potential yield is lost.

Communications with farmers to determine when sample fields will be harvested is difficult. Few farmers have telephones. Cooperation with local officials (extension agents) is limited and needs to be improved. Extension agents are in contact with the farmers and could inform the sampling office when the field is to be harvested.

5. ASSESSMENT OF PROPOSED FORECASTING PROCEDURES AND MODELS

The critical review and assessment of the procedures used in the study, documented in this chapter and annex E, are intended for the benefit of MALR when it begins to implement the new procedures. Chapter 6 documents many of the lessons learned during the study.

5.1 Staffing and Support

The staffing level in the various agencies of MALR appears to be adequate for the responsibility they have been assigned. The added responsibility of wheat yield forecasting could be absorbed by the existing staff. However the efficiency and productivity of the staff is limited by a lack of training and proper equipment. In the past, support for some activities has been lacking. There seems to be a renewed commitment on the part of EAS management to support wheat yield forecasting and estimating work through its DOS.

5.1.1 MALR Role

The MALR, through its DOS, provided management support and the field staff for conducting the study. Management staff and officers at all levels offered strong support and active participation throughout the study. The Head of EAS and the Under Secretary of CAAE were prominent in their support from the very beginning. The MALR underwrote the entire operational cost, including travel expenses and salary incentives. The DOS provided oversight and the office staff in each selected governorate did the fieldwork. Governorate office personnel demonstrated a strong interest in the study and eagerly worked on their scheduled days off, and sometimes spent 10 hours a day in the field to accomplish the fieldwork in the specified time frame. Agricultural engineers assigned to work on the study, and the sampling office director and deputy director, received special training. Other engineers were trained to operate each laboratory. The engineers assigned to the study received salary incentives paid out of the EAS budget.

5.1.2 Wheat Researchers' Role

Agronomists from the agricultural research stations assisted with the pre-survey training and follow-on training each month throughout the study. They played a much-needed role of providing instruction in basic plant physiology and factors that affect productivity. A better understanding of plant characteristics and growth habits, and the factors that affect productivity, prepared enumerators to more ably interpret and report the conditions they observed in the field.

5.1.3 Assessment of Staffing and Support

The organization of the study and the close partnership between MALR, other government agencies, and MVE introduced a new approach to technology transfer. MALR demonstrated its commitment to improving statistics on wheat by its substantial investment in the study. Governorate office staffs are commended for their eagerness to learn the new procedures and work long hours to complete the fieldwork. Participation by researchers from the agricultural experiment stations was a totally new idea. These agronomists and plant breeders provided a level of training never before available to the governorate offices' staffs. The professional status, experience, and expertise of the study team members assembled by MVE provided needed technical and professional support. Two team members were responsible for supervising field and laboratory activities. This was another new innovation in project management. The two former governorate sampling office directors provided the close supervision needed to assure that correct procedures were being followed. The two supervisors, are known and respected by most of the enumerators, and were a great asset to the field staff. The result of the combined efforts of these groups was a study accepted and respected by data users.

5.2 Pre-Survey Preparation

The success of this study was due in large part to the detailed pre-survey planning by the team. A complete plan for completing the study was in place before training started in late January. Although some of the governorates had previous experience with objective yield forecasting, the study plan introduced a new approach to implementation and operation. Forecasting surveys require a precise and often tight time schedule. The plan included timing for the monthly yield visits, training schedule, training sites and preparation of survey materials. Everyone involved in the study understood the plan and his role in carrying it out.

5.2.1 Survey Equipment and Supplies

Description. Each team of field enumerators needs a measuring tape, frame for laying out plots, clipping shears or scissors, and steel stakes. Disposable supplies include wood pegs, cord or string, flagging tape, flag poles, paper bags and reporting forms. Laboratory equipment includes electronic balances, a drying oven, and pans and other containers for holding lab samples. Some governorates had equipment carried over from the mid-1980's ADCAP. The condition of all existing equipment was checked and additional items procured as needed.

Forms were prepared and supplied by the team. Each governorate was responsible for obtaining its own survey supplies.

Assessment. Flagpoles for making the plots were inadequate in many fields. Materials used for flagpoles included corn stalks, sugarcane stalks, palm fronds, bamboo or no pole at all. Clearly, the enumerators did not bring these items to the field, but used whatever could be found on site. Bamboo is the preferred material for flagpoles because it is lightweight and can be easily transported and is available in the proper lengths.

Clearly making the location of the plots is very important so they can be easily found on return visits. Quite often on the return visits, valuable time was lost searching for the field plots, and in a few instance plots couldn't be found. When a plot can't be found, an alternate plot is laid out. As a result, the value of all information gathered in previous months is lost for determining survival ratios.

Flagging tape should be used to subdivide the count area and clip area. It is more visible than cords and makes it easier to find the plot on return visits.

A wide variety of sizes and qualities of supplies were used in different governorates. For example, the style and size of paper bags used was different in almost every governorate. Some of the bags were too small, and wheat heads were damaged when too many were crammed into a bag. In some governorates two bags were required to hold all the heads when the plot count area was harvested. This increased the chances that one bag will be lost, damaged or mislabeled.

The addition of a clipboard or clear plastic folder to hold the forms would be a good addition to the enumerator's supplies. As discussed in section 5.5, enumerators need to carry the forms into the field and record counts and measurements directly on the forms. Some method of securing and protecting the forms would be helpful.

5.2.2 Reporting Forms

Description. Field counts, measurements and observations and laboratory analysis are recorded on specially designed forms. Forms used in the study include: Form A for diagramming the sample cluster and sample field, showing directions to the sample cluster and the location of the plot; Form B for recording field counts and observations; Form C-1 for recording field counts of plant parts to be sent to the laboratory when fields are in maturity stage 3, 4, or 5; and for recording the counts and measurements made in the laboratory; Form C-2 accompanies field samples to the laboratory when the count area is harvested (maturity stages 6 and 7); Form C-3 is for recording special research study of a sample of five emerged mature heads; and Form E is for recording field counts and measurements and laboratory analysis for post-harvest gleanings. Two different ID tags are used for transmitting field samples to the laboratory. All forms were designed specially for the study by the team. Simplicity, clarity and promoting accuracy were the main considerations in designing the forms. (See annex D for a complete set of forms)

Maintaining consistency of operation across all survey sites is critical to achieving high-quality survey results. Detailed instruction manuals, printed in Arabic, covering field and laboratory procedures were given to each enumerator and laboratory staff. Instructions for laying out the plots and completing the monthly plant counts and measurements are also printed on the reverse side of Form B. Instruction manuals and the forms were covered in the pre-survey training and reviewed each month before fieldwork started. Even with this intense training, it was very difficult to teach the enumerators the importance of accurate and precise work.

Assessment. Development and maintenance of forms and instruction manuals is a continuous process. Although it is not always practical to make changes to forms during the survey, problems with using forms need to be noted. Items on the forms that are not clearly understood by enumerators, or that cause inconsistent reporting, need to be emphasized by supervisors. Forms should be reviewed and updated after each survey. This is the best time to make needed changes and add or delete items.

The form B used in the ADCAP was used in January and found not to be adequate. A new form B was designed and ready for the February field visit. Slight revisions were made to some of the forms as the study progressed to make them more useful or easier to use.

Instruction manuals should be conscientiously updated and revised and include all current operating procedures. The resolutions of significant that occur during the survey cycle should be issued as addendums to the manual. All addendums and notes accumulated during the survey need to be incorporated into the manual at the end of the survey.

5.3 Sampling Technique

5.3.1 Description

For maximum economy and to reduce the cost of wheat yield forecasting fieldwork, it was proposed to use the same frame as for crop cutting surveys. And select a sub-sample of governorates, districts and clusters. Usually the crop cutting surveys provide estimates of yield for individual governorates and its administrative districts and for the national level.

Pre-harvest yield forecasts at the national meet the needs of decision makers for planning. This keeps to a minimum the increase in budget and resources needed to carry-out crop forecasting.

The sampling design was a modified stratified multi-stage sampling. This was achieved as follows:

- Six governorates were pre-selected. Four represent Lower Egypt (Beheira, Gharbia, Kafr El Sheikh and Sharkia), and two represent Upper Egypt (Fayoum and Assuit). New Lands were represented by Nubaria, which includes Bangar El Sokar and Bustan regions.

- Two districts in each governorate were pre-selected. Governorate and district selection were based on previous experience and wheat area cultivated, rather than random selection. The total area of wheat cultivated in the sample governorates (about 1.3 million feddan) and constitutes about 50% of the total wheat cultivated area in the country (Table 3.1).

- A number of clusters (each of about 200 feddans cultivated area) were selected in each district.

- Two clusters were randomly selected in each of the selected districts (in all governorates except Assuit, where two clusters were added for durum wheat). These were examined in the order of random selection as to whether they grew wheat crop. It was found that all the selected clusters had wheat and most of them included various wheat varieties grown in the district.

- For each cluster a supplementary form (Form 3 of crop cutting sample) was filled out for the selection of parcels. With the help of village officials, a list of holders growing wheat in the order of the location of the land can be prepared for each *hode* comprising the cluster.

- Two wheat crop parcels were selected at random out of all the parcels growing wheat in each of the selected clusters. This constituted the second stage of sampling.
- In each of the selected parcels, a field growing wheat was selected at random out of all of the fields growing wheat crop in the parcel (with the help of physical boundaries 0.50 m and more inside the parcel). This formed the third stage of sampling.

- Within each of the selected fields two plots 120 cm x 60 cm in size were randomly selected (the fourth and last stage of sampling). For this purpose the length and width of the selected field were measured in meters starting from the southwest corner of the field. After deducting 1.2 m from the length and 0.6 m from the width, two pairs of random numbers were selected for the location of the two plots. If the two plots overlapped another pair of random numbers was selected so that the two plots were located apart from each other in the same field. A sketch of the field was made on form A showing the location of the two plots (details in annex D).

Total sample size was 112 plots. Since the main objective of this study was to demonstrate objective yield forecasting technique and train staff, no attempt was made to calculate optimum sample size for forecasting. However, Using the variance from this study to compute optimum sample size, 200-300 sample field would be needed for a representative nationwide forecasting survey. See section 6.3.2.

After finishing the survey, cluster numbers, field numbers within cluster, plot numbers within field could be calculated for several levels of precision and at given cost.

The sample was selected following the procedures outlined in sections 2.2 and 4.2. Table 3.1 shows details of the sample distribution.

5.3.2 Assessment

One of the main objectives of the study was to test and evaluate objective survey methods for forecasting. The procedures used to select the sample fields fulfilled that purpose, although the process was not completely random. The seven governorates in the study were pre-selected to be geographically representative for growing the major wheat genotypes and varieties.

Placing two randomly located plots in the sample field is a departure from any previous yield survey procedures in Egypt. One advantage of this procedure is that it provides an additional observation at very little added cost. Additionally, it provides survey data needed and compute variances at all levels of the sample.

5.4 Training

Training is one of the most important aspects of the survey plan. Intensive training was scheduled before the survey started, and follow-up sessions were held before each field visit. The initial training activities and the March follow-up session are described in detail below. The February and April follow-up sessions differed from March only in the emphasis placed on the current growth stage of the plants. The only mention of the February and April sessions in sections 5.4.1 and 5.4.2 point out differences when compared with the January and March sessions. Chapter 6 shows details of each training session.

5.4.1 Field Procedures Training

Description. The initial training was two full days in each selected governorate before fieldwork started in January. Training on agronomic characteristics of wheat was held at the agricultural research stations in or near the study sites. An agronomist from the research station gave classroom instructions on characteristics of the wheat plant; wheat varieties; growth stages; factors that affect productivity like weather, fertility, insects, diseases, weeds, etc. A wheat researcher explained the yield triangle (number of spikes, number of kernels per spike and weight per kernel) from a plant breeding perspective. Following the classroom sessions the trainees went to the field to observe wheat plants growing and for hands-on experience in applying the classroom instructions.

The second day was devoted to instruction on survey operations, survey administration and field procedures by the team members and field supervisors. Subjects covered included sample selection, locating and diagramming the sample cluster and field and measuring field dimensions, random location of plots within a sample field, laying out the plots and designating the clip and count areas, determining maturity stage, and discussion of questions raised by the trainees. Following the classroom training, the trainees went to the field and started to do their assigned work under the supervision of the study team members and the field supervisors.

At the end of the training all enumerators were given an instruction manual in Arabic.

Training for the March field visit included instruction in each governorate sampling office and hands-on demonstrations in the field before starting data collection. About two hours were spent in the sampling office discussing the growth stages and other plant characteristics the enumerators would find on this field visit, and going over the survey procedures. The wheat researchers talked about the maturity stages enumerators would find in the field, and how to distinguish between flower, milk, soft dough and hard dough maturity stages. How to identify plant diseases, insects and predator damage was also discussed. The team reviewed the Form B, C-1 and C-2, and the ID tag for transmitting the field sample to the laboratory. Emphasis was placed on minimizing damage to plants in the sample field, especially in and around the plots. Forms for the March field visit were distributed.

Assessment. In the field, the wheat researcher demonstrated how to determine the various maturity stages. Examples of weeds, plant diseases and insect and predator damage were observed. The wheat researchers are an important part of the training. Having knowledge about the characteristics of wheat plants and the factors that affect production gives the enumerators greater confidence to do their work.

Hands-on instructions on current month field procedures were provided for all enumerators at the first plot of the first sample visited by the team and field supervisors. After the first plot was completed, the enumerators separated into the teams assigned to each district and proceeded to complete the remaining samples. Members of the study team and/or the field supervisors accompanied each team to all of their assigned fields.

Training for April field visits followed the same pattern as in March. Procedures for harvesting the count area were covered in April because about 90% of the sample plots were in maturity stage (six or seven stage) and harvested on the April visit. Plots that were not ready to harvest on the fourth visit were closely monitored and harvested as soon as they reached maturity stage 6. Procedures for laying out the post-harvest gleanings plot and completing the Form (E) need to be covered in April.

5.4.2 Laboratory Training

Description. Training of the laboratory staff started in February when the earliest fields were in maturity stage three. The team instructed the lab staff in proper handling of the samples as they arrived from the field. Counting and measuring procedures were demonstrated for the heads from clip block one. The wheat researchers showed the technicians how to identify fertile spikelets and count the number of grains per spikelet.

Assessment. Enumerators entered the training at a very low knowledge and skills level but responded with great enthusiasm. Any training they had received in the past did not emphasize the level of accuracy and precision necessary for using small plots for forecasting. Staff had difficulty grasping the importance of strictly following the survey time schedule and the procedural instructions. Rushing to complete the fieldwork, enumerators often ignored proper procedures, which resulted in procedural errors. Their experience with crop cutting surveys, where there is no need to be concerned about damaging the plants in and surrounding the sample plot, did not prepare them for the forecasting work. It is necessary to maintain the plot in its original condition during the pre-harvest visits so the plants harvested at maturity will be representative of the plants in the field. In summary, the training plan was very effective and enumerators showed steady progress in following proper procedures and turning out higher-quality work as the season progressed.

The input from the wheat researchers was one of the most beneficial parts of the training. Enumerators learned about the characteristics of wheat plants and the factors that affect productivity. Having a better understanding of conditions they saw in the field improved their quality of work.

Total formal training during the study amounted to about 20 hours. In addition to the formal classroom and full sessions, the entire survey process was a training exercise. A team member or field supervisor accompanied enumerators on every field visit. Although training cannot be overemphasized, it is not reasonable to sustain this level of training in an operational survey program. However, the duration of training can be reduced as staff gain experience in survey operation The engineers that worked on the study are prepared to teach, and work alongside, new enumerators in the future.

5.5 Data Collection

The level of detail required in the fieldwork was a new experience for the enumerators. Despite the intensive training and close supervision, it was difficult to get enumerators to understand the importance of doing precise work.

Four pre-harvest visits and the harvest visit were made to the sample fields. After the field was harvested, the enumerator returned within three days of harvest to gather post-harvest gleaning to determine harvest loss. The pre-harvest data collection periods were: Jan. 22 – Feb. 7, Feb. 22 – Mar. 1, Mar. 23 – Apr. 2, and Apr. 20 – May 1. These dates were set during pre-survey planning. It is very important to adhere to the established schedule for several reasons. First, keeping the pre-set schedule shows respect for the survey process. Second, it holds offices accountable for meeting the schedules. Third, and most important, is the value added to the survey data. The historic averages computed from the survey data, and used in early season forecasting models, more accurately represent the current situation when the same survey schedule is maintained from year to year. Any sample fields that were not in maturity stage 5 on the April visit were closely monitored and harvested when they reached maturity stage 6. About ninety percent of the plots were harvested on the fourth visit. In a few cases, plots in maturity stage five were harvested. This is acceptable if the farmer is planning immediate harvest of the field or the peduncle and flag leaves are completely dead.

5.5.1 Field Procedures

Locating the sample field and laying out the plots. The first field operation is locating the sample parcel and selecting the sample field from the wheat fields in the parcel. This procedure is the same as used in crop cutting, so the enumerators had some experience in this regard. After identifying the sample field, the sample cluster and the field showing the location of the plot are diagramed on Form A. Enumerators keep Form A to use in locating the field on return visits. Sample identification information such as governorate, district, stratum, village, *hode*, cluster, parcel and farmer name are entered on all of the forms. Planting date, planting method, date, time and purpose of the field visit are recorded on Form B.

The dimensions of the field are measured and recorded on Form A and Form B. Coordinates for locating the two plots within the field are selected from a table of random numbers and recorded on forms A and B. Using a measuring tape the enumerator measures the proper number of meters along the edge of the field and into the field to find the plot location. Two adjacent 60cm x 60cm sections are laid out in a south to north direction to establish plot one. Using the frame, the four sides of the two sections are established and wood pegs are used to mark the corners. The diagonals of the sections are measured to assure that the sections are square. The southwest 60cm x 60cm section is the count area and the second section is the clip area. The count area is divided into quadrants to facilitate counting of plants. The clip area is divided into six 30cm x 20cm blocks. Plants from one specified block will be harvested each month and the heads sent to the laboratory for analysis. A two-meter long pole with flag tape is anchored in the ground one meter from the southwest corner of the plot to mark its location. Plot two is located and laid out in a similar manner.

Enumerators must take extreme care to avoid damage to the plants in and surrounding the plot on every visit to the field. Plants in the plot must be maintained in their original condition to be truly representative of the plants outside the plot.

Counts and measurements. The field activities to be completed each month are determined by the maturity stage of the plants in the plots. The number of stalks, number of late boot heads, and the number of emerged heads in the count area are counted and recorded on Form B. If plants in the plots are in maturity stage three or higher, the plants in the specified clip block are harvested and the heads sent to the laboratory for analysis. The count area is recorded on Form B by quadrant. When maturity stage reaches six or seven, the plants in the count area are harvested and the heads sent to the laboratory for threshing. Grain from the threshed heads is used to compute final plot yield. Instructions for laying out the plot and making monthly counts and measurements are recorded in the instruction manual and on the reverse of Form B.

Other measurements and observations. Observations of conditions like irrigation; humidity; weeds, insects, and diseases infestation; predator damage; lodging and plant density are recorded on Form B. This information will be useful when reviewing the field data in the office. Factors affecting productivity such as fertilizer, pesticides, weather, seed source, and seeding rate are obtained from the farmer.

Measurements are made for plant height, and flag leaf length and width. Studies are planned to determine if these factors are correlated with the weight of heads at maturity or not .

Counts and measurements from Form B are copied to Form C-1, or C-2 and Form B is sent directly to the office for processing.

Sending field samples to the laboratory. Form C-1 accompanies field samples in maturity stages 3, 4, and 5 to the laboratory. Form C-2 is used when the count area is harvested, at maturity stages 6 and 7. Form C-3 is for a special study of five heads from plots in maturity stage 6 and 7. Different color identification tags are used for plants from the clip area and plants from the count area.

The laboratory sample for plots in maturity stage 3, 4, and 5 consists of the heads from a specified clip area. The green weight and dry weight of these heads are used in the head weight model. The number of fertile spikelets and the number of grains per spikelet are used in the grains per head model. Other measurements such as head length, head diameter, and stem diameter are made for research purposes.

The laboratory sample for plots in maturity stage six or seven includes all of the heads harvested from the count area. Heads are threshed and the grain is weighed, then dried, and re-weighed to determine moisture content. The weight is corrected to 12.5% moisture and used to compute the final plot yield.

5.5.2 Laboratory Procedures

The laboratory work is very detailed and requires a great deal of patience. Technical skill is also needed to identify fertile spikelets and kernels in the spikelets. Planning and organization is necessary to operate the laboratories efficiently. Samples arriving from the field must be clearly labelled and tracked throughout the lab processing to avoid samples getting mixed. The processing of clip block samples of immature heads requires great care to assure accurate counting of fertile spikelets and kernels, and are the most time-consuming to process.

Threshing the mature heads harvested from the count area is more straightforward, but also must be handled with care. The loss of a few grains can have a huge effect on the sample yield. The samples are threshed by hand, which is difficult and time-consuming. A few sample plots were harvested in maturity stage five because the farmer was ready to harvest the field. This had to be done to prevent losing the sample. Although heads in maturity stage five are physiologically mature they are high in moisture and must be either air or oven dried before threshing. This extra step presents another opportunity for samples to get mixed with other samples or to be mislabeled.

Determining moisture content of the grain is a critical step that requires care to prevent losing threshed grains. Moisture determination requires weighing the threshed grain, oven drying, then reweighing it. The MALR is planning to acquire moisture meters for the labs before next season. This will speed up the lab processing.

5.5.3 Assessment of Field and Laboratory Procedures

It is recognized that this was a study, and some of the field procedures were not conducted under operational conditions. However, the observations below are offered to assist with making preparations for future surveys. The field staff is commended for its efforts and progress during the study. Skills and performance improved with each field visit, and by the end of the study enumerators had gained a better appreciation for strictly following the procedures. Although the interest level was high, the precision and the details required caused some problems for the enumerators. Their experience with crop-cutting did not adequately prepare them for the forecasting work.

Finding the plot, and in some cases even the sample field, on the return visits was often a problem. Much time was lost searching for plots. In a few cases the plot couldn't be found. When this happens, the value of the data collected on previous visit is rendered useless for modelling purposes. An alternate plot can be laid out and the data used for current month computations, but this also takes extra time. Enumerators need to carry the frame and all other materials needed to lay out a plot. Some plots were relocated without using improper procedures and materials. Failure to diagram the cluster and field properly and using inappropriate flagpoles to mark the location of the plot were major factors contributing to difficulty in finding the plots.

Excessive damage to plants in and around the plots often occurred. This was a study, and training sometimes took precedent over observing proper field procedures. Several people were often in the field when there should have been no more than two. For training purposes in the future, alternative plots need to laid out in the sample field. Preventing damage to the plot must be emphasized.

When selecting sub-samples of heads, care must be taken to use random procedures. The first five heads from the clip block are used in the average weight per head model and need to be representative of all of the heads in the plot. There is a tendency to pick the largest heads first. Selecting heads larger than the field average gives a false indication of head weight that carries over into the forecast.

Care must be taken to include plants and heads of all sizes, whether alive or dead, when counting. Quite often small heads and plants thought to be insignificant were overlooked. The result of ignoring the smallest heads in the count area is the same as described above for the five random heads.

Identification information should be entered on forms in the office and all field counts and measurements recorded directly on the Form B. Enumerators often didn't take Form B into the field and recorded counts and measurements on a variety of material and transferred the readings to the Form later. This increases the chance for errors and takes extra time.

Using paper bags too small to hold all of the plants from a plot causes damage to the heads by packing them into the bag. Bags were sometimes not securely closed and heads spilled out. ID tags were sometimes separated from the bags.

The laboratory staff did an outstanding job while working under very difficult conditions. They worked on their scheduled days off and spent long hours in the lab to finish the work on schedule. The work is hard and requires a high level of concentration to maintain accuracy. The moisture metres will improve working conditions for next season. Laboratory threshers would be a great addition the labs to enhance productivity.

5.6 Supervision and Quality Control

5.6.1 Description

A strong program of field and laboratory supervision was maintained throughout the study. Enumerator teams were accompanied by a team member or a field supervisor on every field visit. The purpose was twofold. The primary purpose was training the enumerators in proper field procedures. Additionally, the close supervision assured that the survey results were consistent across all survey sites. Although the purpose of the study was not to produce a definitive forecast of yield, data consistency was important.

Forms B were sent directly from the field to the MVE office, where the data were entered into EXCEL spreadsheet files. When the laboratory analysis was completed, the Form C data were entered. All survey forms were manually reviewed for completeness and to identify any obvious errors. Current months forms were compared with previous months reports as a check for consistency. Form B data was also compared with Form C data for consistency. Differences were resolved by consulting with the field supervisors and the lab staff.

5.6.2 Assessment

The supervision and quality control for the study was carried out in a manner, and at a level, that probably can’t be sustained in an operational environment. Either a team member or a field supervisor accompanied the enumerators on every field visit. Training was the main objective of this intense interaction between the team and the field staff. The results were a highly-trained enumerator staff and consistency in the survey results. Another benefit of the close supervision was the interaction between EAS staff and the research station personnel. The two field supervisors are former governorate sampling office directors with previous experience in wheat and cotton forecasting studies, added a valuable dimension to the fieldwork. They related well to the enumerators and helped to create a compatible working atmosphere.

5.7 Data Processing

Field enumerators count and measure several items within or near the plots. Data items are used to measure, plot size, number of heads, weight per head and harvest loss.

The following are the data items collected and intended uses of these measurements:

< Data items used to measure the size of each plot:
The distance of the four dimensions of each plot and plot diagonal (to adjust plot size to 60 cm x 60cm).

< Data items to forecast or estimate the number of heads:
- Number of stalks (stems) in each plot.
- Number of late boot heads in each plot.
- Number of emerged heads in each plot.

< Data items used to forecast or estimate kernels weight per head:
- Number of fertile spikelets on 5 heads sample (clip area).
- Number of grains on 5 heads sample (clip area).
- Weight of green emerged heads on 5 heads sample (clip area).
- Weight of late boot heads (clip area).
- Weight of kernels threshed from mature heads per plot.

< Data items used to estimate harvest loss:
- Two plots (60 cm x 60 cm each), post-harvest.
- Kernels weight of heads per plot.
- Loose kernels weight per plot.

It should be mentioned that the collected data were checked and reviewed three times at various levels (at the governorate sampling office, at the head office before entering data, and after the data entry) before conducting the data analysis.

5.8 Statistical Analyses

5.8.1 Wheat Farm Size in the Sample

Table 5-1 shows that about 39% of sample fields were less than 0.5 feddan in size. About 29% were 0.5 feddan to one feddan, 14% were between one feddan and two feddans, 14% were between two feddans to three feddans, and only 4% of field size were more than three feddans.

Table 5-1: Frequency Distribution of Wheat Farm Size of the Sample

Farm Size Classes	Frequency	Percent %	Cumulative Percent
≤ 0.5 feddan	22	39	39
- one feddan	16	29	68
- 1.5 feddan	6	10	78
- 2.0 feddan	2	4	82
- 2.5 feddan	1	2	84
- 3.0 feddan	7	12	96
More than 3.0 feddan	2	4	100
Total	**56**	**100**	

Source: Calculated and compiled from wheat yield forecasting survey data 2000.

5.8.2 Planting Dates of Wheat Yield Forecasting Survey Sample

Table 5-2 shows the distribution of planting dates. November is the most favorable time to plant wheat and yield potential is reduced for planting after December 30. Slightly over 75% of the sample fields were planted during the most favourable planting period.

Table 5-2: Frequency Distribution of Planting Dates of the Sample

Date of Planting	Frequency	Percent %	Commutative Percent
First half of November	15	27	27
Second half of November	28	50	77
First half of December	9	16	93
Second half of December	4	7	100
Total	**56**	**100**	

Source: Calculated and compiled from wheat yield forecasting survey data 2000.

5.8.3 Harvesting Dates of Survey Sample

Table 5-3 shows the distribution of sample field harvest dates. The first sample field was harvested on April 20 and all fields were harvested by May 9. Nearly 90% of the sample fields were ready for harvest by the third and fourth field visit.

Table 5-3: Frequency Distribution of Harvesting Date of the Sample Survey

Valid	Frequency	Percent	Cumulative Percent
22-Apr-00	4	3.5	3.5
23-Apr-00	2	1.8	5.3
24-Apr-00	6	5.3	10.6
25-Apr-00	10	8.8	19.5
26-Apr-00	13	11.5	31
27-Apr-00	14	12.4	43.4
29-Apr-00	14	12.4	55.8
30-Apr-00	11	9.7	65.5
02-May-00	20	17.7	83.2
06-May-00	10	8.8	92
07-May-00	3	2.7	94.7
08-May-00	2	1.8	96.5
09-May-00	4	3.5	100
Total	**113**	**100**	

Source: Calculated and compiled from wheat yield forecasting survey data 2000.

5.8.4 Comparison between Survey, Research Station and AERI Wheat Yield Forecasting Estimates

Table 5-4 demonstrates that the survey number of spikes per m^2 for all varieties except Gimmiza 5 were within range of research data. The average is $366/m^2$ for the survey, $350-450/m^2$ for research, and about $425/m^2$ for AERI data.

Number of grains per spike was different for most of varieties for survey data and research data except Giza 164. Varieties Sakha 69, Sakha 61, and Gimmiza 5 were less than research by about 7-8 gm/spike, but for Durum, the survey data was greater than research data by about 7 gm/spike.

The overall average was 45.19 grains/spike for survey against 52 grains/spike for research data. No data is available for AERI.

Average weight of kernels per head shows more difference between estimates. Most of survey varieties were less than research data except Durum and Giza 164. The overall average was 1.89 against 2.51. For special survey sample (5 spikes near every plot) seems to be very close.

These differences between research station data and the survey data are within expectations. The controlled environment under which the research plots were grown should produce higher yield estimate than the randomly selected farmer's field. Data of AERI were less than both (1.56 average head weight).

5.8.5 Comparison Between Varieties and Governorates

- Analysis of variance, Table 5-5, showed no significant difference in yield among all varieties.
- ANOVA showed the same results for the different governorates of the study, Table 5-6.
- For variety Sakha 69 which was common in all governorates, a one way ANOVA was conducted, also insignificant, Table 5-7.
- ANOVA which includes both varieties and governorates proved that only the interaction between governorate and variety was significant at the 0.035 level, Table 5-8.

Table 5-4: Comparison between Survey, Research Stations and AERI Wheat Yield Forecasting Estimates

Varieties	Number of Spikes/m^2			Number of Grains/Spike			Weight/Head (gm)			
	Survey	Research	AERI	Survey	Research	AERI	Survey (1)	Survey (2)	Research	AERI
Sakha 69	366	350-450	-	43.01	50	-	1.71	2.32	2.40	-
Sakha 61	400	300-400	-	40.54	50	-	1.64	2.32	2.60	-
Sakha 8	436	350-450	-	52.80	50	-	2.17	2.80	2.10	-
Giza 164	378	350-450	-	54.73	55	-	2.51	2.77	2.42	-
Gimmiza 5	222	450-550	-	44.10	55	-	2.16	3.14	2.64	-
Durum	387	320-380	-	57.15	50	-	3.09	3.51	2.90	-
Total	**366**	**350-450**	**425**	**45.19**	**52**	**-**	**1.89**	**2.42**	**2.51**	**1.56**

Source: Wheat Yield Forecasting survey 2000 and AERI reports (annex E).

5.9 Forecast Models and Applications

5.9.1 Regression Models

The forecast models have the following form:

$Y_i = a + bx_i$

Where
Yi = Number of heads or weight per head.
a = Number of heads or weight per head when x equals zero.
b = The change in number of heads or weight/head for each unit increase in x_i

Xi = The independent measurements: number of stalks, number of emerged plus late boot heads, number of fertile spikelets/head, number of grains/head or weight/head.

5.9.1.1 Forecast Number of Heads (Y_n)

$Y_i = a + bx_i$
Where X = number of stalks, or
X = number of emerged and late boot head.
Notice that the out layers were excluded (2-7 plots), most of them in new lands.

A. Plot level

Table 5-9 contains a group of regression models for the several visits and maturity categories. Based on plot counts as a database to forecast number of heads, all models are highly significant.

First Visit (January 27-February 07, Maturity Stage 1,2)

Y = $51.4 + 0.49\ X_{11}$

Where

Y forecast number of heads

X_{11} number of stalks in the first visit (late of Jan.)

R 0.71

R^2 0.51

Table 5-5: ANOVA for Total Head of Different Varieties, Harvest visit

S.O.V.	Sum of Squares	df	Mean Square	F	Sig.
Between Varieties	10056.35138	5	2011.270276	1.460907	0.208728
Error	147309.8433	107	1376.727508		
Total	157366.1947	112			

Table 5-6: ANOVA for Total Head of Different Governorates, Harvest visit

S.O.V.	Sum of Squares	df	Mean Square	F	Sig.
Between Governorates	8277.10469	6	1379.517448	0.980815	0.442012
Error	149089.09	106	1406.500849		
Total	157366.1947	112			

Table 5-7: ANOVA for Total Head of Sakha 69 in Different Governorates, Harvest visit

S.O.V.	Sum of Squares	df	Mean Square	F	Sig.
Between Governorates Sakha 69	7540.48081	6	1256.746802	0.906731	0.495845
Error	88705.2375	64	1386.019336		
Total	96245.71831	70			

Table 5-8: Two Way ANOVA for Governorates and Varieties, Dependent Variable: Total Head in the Harvest visit

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	21289.35302	12	1774.112752	1.303758	0.228286
Intercept	670143.7987	1	670143.7987	492.4745	0
GOV	6492.697836	6	1082.116306	0.795224	0.575826
VARIETY	5782.495044	5	1156.499009	0.849887	0.51771
GOV * VARIETY	6208.318699	1	6208.318699	4.562362	0.035123
Error	136076.8417	100	1360.768417		
Total	2112048	113			
Corrected Total	157366.1947	112			

R Squared = .135 (Adjusted R Squared = .032)

Second Visit (February 27-March 01, Maturity Stages 2,3)

$Y = 32.43 + 0.67 X_{12}$

Where

X_{12} the number of stalks in the second visit.

R 0.78

R^2 0.61

Third Visit (March 23-April 02, Maturity Stages 3,4,5)

Two models could forecast the number of heads in this visit:

1) $Y = 18.33 + 0.86 X_{13}$ $R = 0.90$ $R^2 = 0.82$
where X_{13} is the number of stalks in third visit.

2) $Y = 44.50 + 0.72 X_{33}$ $R = 0.83$ $R^2 = 0.68$
where X_{33} is the number of emerged heads in third visit.

Model (1) in the third visit seemed to be better than model (2). Number of stalks still the most important independent variable in this visit. Model (1) generated a higher R^2 than model (2) (number emerged heads + late boot heads) to forecast final number of heads (see table 2-1 for models description).

Fourth Visit (April 20-May 01, Maturity Stages 5,6,7)

One model is the best using number of emerged heads as an independent variable.

$Y = 2.3 + 0.99 X_{34}$ $R = 0.98$ $R^2 = 0.97$

Where X_{34} is the number of emerged heads per plot.

Note that about 65.5% of the plots were harvested in this visit.

Harvest Visit

Final plot harvest started on April 22 and ended May 08.

Y = 131.9 (actual count of emerged heads final).

To be used as historical average in the next year.

B. Field Level (Plot 1 + Plot 2 within field)

Table 5-10 based on field level data (plot 1 + plot 2). It includes also the same models with R^2 equal 0.58, 0.65, 0.81, 0.77, and 0.98 respectively.

5.9.1.2 Forecast Threshed Grains (Kernels) Weight/Head (Y_w)

$$Y_w = \frac{R_1^2 (Y_{w1}) + R_2^2 (Y_{w2})}{R_1^2 + R_2^2}$$

Where

Y_w = combined weight per head from forecast models (1) and (2) weighted by R^2 Values.

Y_{w1} = forecast weight per head from model (1).

Y_{w2} = forecast weight per head from model (2).

R_1^2 = multiple correlation coefficient for model (1).

R_2^2 = multiple correlation coefficient for model (2).

A. Plot Level

Table 5-11 demonstrates the models for plot level.

- **First Visit** (late January)
  Only historical average use

- **Second Visit** (late February)

Three models were used to forecast average weight/head:

1) $Y_1 = 0.382 + 0.641 X_{12}$ R = 0.69 $R^2 = 0.48$
Where X_{12} is the average weight of green head.

2) $Y_1 = 0.725 + 0.325 X_{22}$ R = 0.74 $R^2 = 0.55$
Where X_{22} is the average weight of late boot (enclosed head with flag leaf)

3) $Y_1 = 0.704 + 0.134 X_{32}$ R = 0.67 $R^2 = 0.45$
Where X_{32} is the average number of fertile spikelets per head.

- **Third Visit**

Only one model was used to forecast final weight per head.
$Y_1 = 0.676 + 0.0263 X_{43}$ R = 0.76 $R^2 = 0.58$
Where X_{43} is the average number of grains per head.

- **Fourth Visit**

Two models out of four models could be used to forecast average weight of head.

1) $Y_4 = 0.162 + 0.652\ X_{14}$ $\quad R = 0.92 \quad R^2 = 0.85$

Where Y_4 is the final weight/head from 5 spikes sample.
X_{14} is the average weight of green head in fourth visit.

2) $Y_4 = 0.0045 + 0.0537\ X_{44}$ $\quad R = 0.86 \quad R^2 = 0.74$

Where X_{44} is the average number of grains per head (fourth visit).

- **Harvest Visit**

Actual threshed weight per head adjusted to standard moisture determined by the laboratory.
$Y_1 = 1.86$ Use as historical average in the next year.

B. Field Level

Table 5-12 demonstrates the models for field level. The results are close to plot level's results.

These models need to be supported with other models in additional two years as a database (3-5 years). After five years, we have to drop one year and add another one.

5.9.2 Survival Ratio Models (S.R)

$$S.R. = \frac{\text{Final emerged head number}}{\text{Number of stalks or number of emerged heads in the visit}}$$

Forecast Number of emerged heads can be obtained as follows:

= Number of stalks x $S.R_1$ or
= Number of emerged heads x $S.R_2$ or
= (Number of emerged heads + late boot) x SR_3

Table 5-13 shows the survival ratios for every visit. The ratios were as follows:

- Visit (1): $S.R_1 = 0.84$
- Visit (2): $S.R_1 = 0.91$
- Visit (3): $S.R_1 = 1.00$
- Visit (3): $S.R_2 = 1.05$
- Visit (4): $S.R_2 = 1.01$

Table 5-9: Forecasting Total Number of Heads, Plot level

Maturity Category	Model	Independent Variable	Form	F	R	R^2	N	x`	y`
First Visit Late Jan. (1,2)	1	Stalks Number First Visit	$Y = 51.4^{**} + 0.49\ X_{11}^{**}$ (6.58) (10.65)	113.35**	0.71	0.51	112	161.04	
Second Visit Late Feb. (2,3)	1	Stalks Number Second Visit	$Y = 32.43^{**} + 0.67\ X_{12}^{**}$ (4.12) (13.1)	172.34**	0.78	0.61	113	147.72	
Third Visit Late March (3,4)	12	Stalks Number Third Visit Emerged Head Third Visit	$Y = 18.33^{**} + 0.86\ X_{13}^{**}$ (2.52) (20.83) $Y = 44.50 + 0.72\ X_{33}^{**}$ (6.12) (0.047)	481.01** 222.27**	0.90 0.82	0.82 0.67	110 111	133.84 123.09	
Fourth Visit Late April (5,6)	1	Emerged Head Fourth Visit	$Y = 2.30 + 0.99X_{34}^{**}$ (1.1) (64.63)	4177.73**	0.98	0.97	113	130.50	131.52
Harvest Visit (6,7)		Actual Count of emerged heads and detached heads	Y = 131.9						

Y = Total number of Heads
X_{11} = Stakes Number first visit
X_{12} = Stakes Number Second visit
X_{13} = Stakes Number Third visit
X_{23} = Late Boot Third visit
X_{33} = Emerged head Third visit
X_{34} = Emerged head Fourth visit

Table 5-10: Forecasting Total Number of Heads, Field level

Maturity Category	Model	Independent Variable	Form	F	R	R^2	N	x`	y`	S.E.
First Visit Late Jan. (1,2)	1	Stalks Number First Visit	$Y = 93.89^{**} + 0.50\ X_{11}^{**}$ (4.64) (8.38)	70.3**	0.76	0.58	52	326.20		39.09
Second Visit Late Feb. (2,3)	1	Stalks Number Second Visit	$Y = 58.48^{**} + 0.70\ X_{12}^{**}$ (2.73) (9.84)	96.77**	0.8	0.65	55	293.40		37.46
Third Visit Late March (3,4)	12	Stalks Number Third Visit	$Y = 40.02^{*} + 0.85\ X_{13}^{**}$ (2.51) (14.72)	216.78**	0.90	0.81	53	268.57		25.25
		Emerged Head Third Visit	$Y = 62.78^{**} + 0.81\ X_{33}^{**}$ (3.82) (12.78)	163.42**	0.88	0.77	51	252.88		27.74
Fourth Visit (5,6)	1	Emerged Head Fourth Visit	$Y = 1.10 + 1.00X_{34}^{**}$ (1.1) (64.63)	2345.25**	0.99	0.98	56	260.5	262.6	9.37
Harvest Visit (6,7)		Actual Count of emerged heads and detached heads	Y = 263.8							

Y = Total number of Heads
X_{11} = Stakes Number first visit
X_{12} = Stakes Number Second visit
X_{13} = Stakes Number Third visit
X_{23} = Late Boot Third visit
X_{33} = Emerged head Third visit
X_{34} = Emerged head Fourth visit

Table 5-11: Forecasting Final Weight of Head, Plot Level

Visit & Maturity Category	Model	Independent Variable	Final Weight of Head					
			Form	F	R	R^2	M SE	n
First Visit	1	Historical Average						
Second Visit	1	Average weight of green head	$Y_1 = 0.382 + 0.641\ X_{12}$ (1.73) (5.90)	34.83	0.69	0.48		40
	2	Average weight of late boot	$Y_1 = 0.725 + 0.325\ X_{22}$ (5.72) (7.03)	49.43	0.74	0.55		43
	3	Average number of fertile spikelets per head	$Y_1 = 0.704 + 0.134\ X_{32}$ (1.46) (5.17)	26.71	0.67	0.45		34
Third Visit	1	Average number of grains per head	$Y_1 = 0.676 + 0.0263\ X_{43}$* (4.38) (8.15)	66.48	0.76	0.58		51
Fourth Visit	1	Average weight of green head	$Y_4 = 0.162 + 0.652\ X_{14}$ (1.68) (23.97)	574.33	0.92	0.85		106
	2	Average number of grains per head	$Y_4 = 0.0045 + 0.0537\ X_{44}$ (0.032) (17.36)	301.45	0.86	0.74		106
	3	Average weight of green head	$Y_1 = 0.67 + 0.35\ X_{14}$ (3.18) (5.94)	35.28	0.50	(0.25)		
	4	Average weight of grains 12.5% moisture	$Y_1 = 0.4296 + 0.60\ X_{54}$ (2.27) (7.85)	61.58	0.61	0.37		106
	5	Actual threshed weight per head						
Harvest Visit		Actual threshed weight per head adjusted to standard moisture determined by the laboratory	$Y_1 = 1.86$					

Y_1 = Weight of Kernels / head (12.5%) Gm.
Y_4 = Weight of Kernels /head from 5 samples Gm.
X_{12} =Average weight of green heads in the second visit Gm.
X_{22} =Average weight of late boot heads in the second visit Gm.
X_{32} = Average Number of Spikelets / head in the second visit
X_{43} = Average numbers of Grains/ head third visit
X_{14} = Average weight of green heads Gm.
X_{44} = Average Number of Grains / head fourth visit
X_{54} = Average weight of Dry grains/head fourth visit Gm.

Table 5-12: Forecasting Final Weight of Head, Field Level

Visit & Maturity Category	Model	Independent Variable	Final Weight of Head					
			Form	F	R	R^2	M SE	n
First Visit	1	Historical Average						
Second Visit	1	Average weight of green head	$Y_1 = 0.312 + 0.687\ X_{12}$ (1.06) (4.76)	22.68	0.73	0.53	0.084	22
	2	Average weight of late boot	$Y_1 = 0.805 + 0.334\ X_{22}$ * (3.63) (4.16)	17.29	0.63	0.40	0.125	28
	3	Average number of spikelets per head	$Y_1 = 0.168 + 0.105\ X_{32}$ (0.489) (5.48)	29.99	0.77	0.60	0.069	21
Third Visit	1	Average number of grains per head	$Y_1 = 0.715 + 0.029\ X_{43}$ (3.30) (5.41)	29.25	0.69	0.47	0.189	35
Fourth Visit	1	Average weight of green head	$Y_1 = 0.296 + 0.455\ X_{14}$ (0.997) (5.42)	29.40	0.60	0.36		53
	2	Average weight of green head	$Y_4 = 0.242 + 0.630\ X_{14}$ (1.65) (15.12)	228.55	0.90	0.81		53
	3	Average weight of grains/head 12.5% moisture	$Y_1 = 0.16 + 0.78\ X_{54}$	59.67	0.73	0.53		53
	4	Actual threshed weight per head 12.5% moisture						
Harvest Visit		Actual threshed weight per head adjusted to standard moisture determined from the laboratory	$Y_1 = 3.72$					

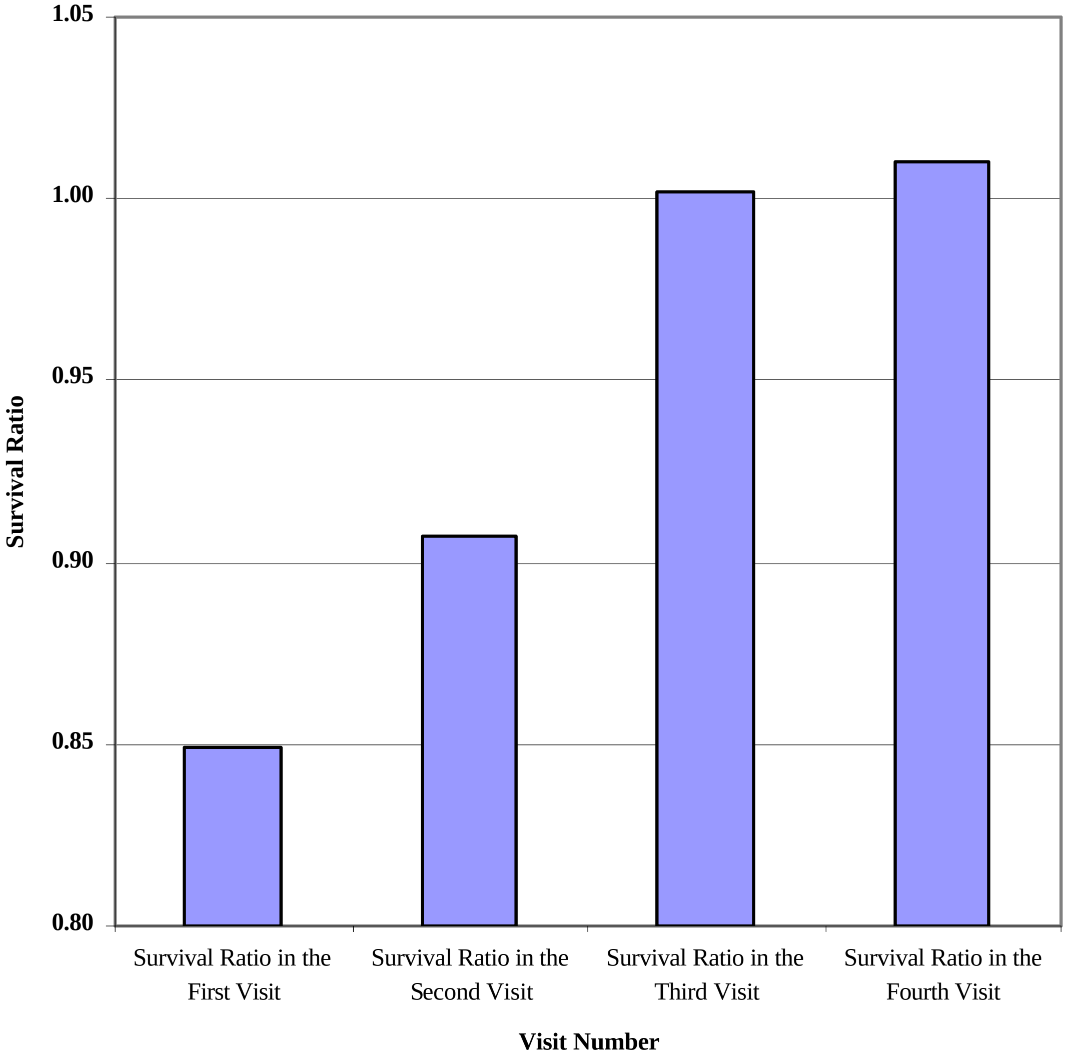
Y_1 = Weight of Kernels / head (12.5%) Gm.
Y_4 = Weight of Kernels /head from 5 samples Gm.
X_{12} =Average weight of green heads in the second visit Gm.
X_{22} =Average weight of late boot heads in the second visit Gm.
X_{32} = Average Number of Spikelets / head in the second visit
X_{43} = Average numbers of Grains/ head third visit
X_{14} = Average weight of green heads Gm.
X_{44} = Average Number of Grains / head fourth visit Gm.
X_{54} = Average weight of Dry grains/head fourth visit Gm

Table 5-13: The Mean and Standard Error for the Survival Ratios

Visit	Survival Ratio	
	Mean	**S.E.**
First Visit*	0.84	0.02
Second Visit*	0.91	0.03
Third Visit*	1	0.01
Third Visit**	1.05	0.02
Fourth Visit**	1.01	0.01

* Total Mature Heads in the harvest visit / Stalks number in the visit
**Total Mature Heads in the harvest visit / (Emerged heads + Late boot)
Source: Calculated and compiled from Wheat Yield Forecasting Survey Data 2000.

Chart 5-1: Survival Ratios in the Four Visits



5.10 Wheat Yield Estimates for Year 2000-Harvesting Visit Results

Actual number of heads and actual head weight, which are obtained during maturity categories 6 and 7 (Hard Dough & Ripe), are used to calculate gross yield per feddan. The following final lab data and gleaning measurements of post harvest grain, are obtained for a plot:

* Number of emerged heads, detached heads, and heads in late boot = 132.7
* Number of heads threshed = 131.9
* Threshed weight of kernels (12.5%)* moisture content = 245.2 gm.
* Post-harvest gleaning kernels 12.5% = 2.4 gm.

Calculated weight per head, gross yield per feddan, harvest loss and net yield:

* Weight per head = (threshed weight of kernels 12.5%)/number of heads threshed
  = 245.2 / 131.9 = 1.85898 gm.

* Gross yield/feddan = (number of heads) (weight per head) (conversion factor)
  = [(131.9) (1.85898)] [0.07778]
  = 19.07 Erdab

* Harvest loss per feddan = weight of threshed kernels 12.5% x conversion factor
  = (3.38) (0.07778) = 0.26 Erdab/feddan.

* Net yield = gross yield – harvest loss
  = 19.07 – 0.26 = 18.81 feddan (4200 m^2)

* Adjusted net yield for utility coefficient of feddan 0.95 of feddan
  = (18.81) (0.95) = 17.87 Erdab/feddan (3990 m^2)

Table (5-19) summarizes wheat yield estimates-2000

From plot weight to feddan yield:

$$\text{Conversion factor} = \frac{4200\ m^2\ \text{(fed./area)}}{0.36\ m^2\ \text{(plot area)}} * \frac{1}{1000\ \text{gm.X150kg. (weight /Erdab)}}$$

$$= 0.07778$$

* Threshed weight of kernels 12.5%:
  = [threshed weight of kernels (1.0 – moisture content)]/0.875

Table 5-14: Wheat Yield Estimates, Harvest Visit Maturity Stages (Hard Dough & Ripe)

Item	Unit	Average	S.E %	(0.05) Lower Limit	(0.05) Upper Limit
Number of heads per plot.	No.	131.9	2.68	124.925	138.875
Average weight of kernels (12.5% moisture)/head	Gm.	1.859	3.02	1.746	1.972
Average weight of kernels)12.5% moisture(/plot	Gm.	245.2	3.68	227.34	263.06
Conversion factor from plot to gross yield/feddan	Coeff.	0.07778	-	-	-
Gross yield per feddan	Erdab	19.07	3.68	17.68	20.46
Harvest loss per feddan	Erdab	0.26			
Net yield (4200 m^2 feddan)	Erdab	18.81		17.08	20.20
Utility coefficient of feddan (2990 m^2)	Coeff.	0.95	-		
Adjusted net yield to feddan 3990 m^2.	Erdab	17.87		16.23	19.19

The upper limit of the estimates is about 19.19 Erdab/Feddan and the lower limit is about 16.23 Erdab/Feddan (confidence level 95%). Those results are close to the results of crop-cutting.

6. PROPOSED CHANGES TO THE CURRENT SYSTEM

Crop cutting at harvest has been the main method for estimating wheat yield in Egypt since 1956. Various attempts have been made to institutionalize a program for providing reliable pre-harvest forecasts of yield. The survey procedures and training outlined in this report provide the guidance needed to begin yield forecasting in earnest.

6.1 Overview of the New System

The proposed changes will put in place a system for making reliable pre-harvest forecasts of wheat yield. Small plots established in randomly selected fields early in the season, and revisited periodically during the season to make specified counts and measurements, can provide the data needed to accurately forecast final yield. Counts and measurements, and laboratory analysis of heads harvested from the plots, are used in mathematical models to forecast number of heads and weight per head at harvest. The procedures use relatively few sample fields and very small plots. This places a heavy burden of responsibility on the operational staff to maintain a high level of accuracy. Although the basic concepts of using objective field plot data for forecasting are the same as for crop cutting, there are many differences in the two systems. First, the forecasting plots are very small, less than 1/5 the size of the crop cutting plots. Second, forecasting plots are laid out in the sample field early in the season and revisited several times before harvest. Crop cutting plots are laid out and harvested on the same day the sample field is harvested. The main difference, however, is how the plot data are used and the output produced from it. Crop cutting surveys provide an estimate of yield after harvest while forecasting provides a projection of yield at various times during the season before harvest, as well as final at harvest yield.

6.2 Design and Implementation of a New System

The study results showed that early season forecasting methodology is suitable for Egypt. This chapter outlines the procedures for developing a program along the lines of the methods and procedures used in the study. Detailed procedures for designing and conducting the surveys and using the survey results to make forecasts are covered in Chapter 5 and the Annex of this report. Implementation can begin with the next wheat season (2000-2001).

6.2.1 Responsibility for Implementation

The decision to begin this new work must come from the top management in MALR and EAS. It calls for a major commitment of support in the form of resources and the empowerment of operational level staff to move forward with implementation and operation. The image of crop forecasting needs to be raised to a level that gives it the same status as crop cutting. This will draw engineers into it as the best way to advance in the organization. Too many times in the past, initiatives like this have faded from the scene as soon as donor funding ended. The support EAS gave to the study at all levels was a good sign that top management is committed to making early season forecasting a part of its regular statistics program. Putting the program into operation then becomes the responsibility of CAAE staff at all levels. Changes in organizational structure are needed to shift the responsibility for some functions closer to the operational level. The decentralized responsibilities will put governorate offices in a better position to use their knowledge of local conditions to improve the quality of forecasts.

A program of this scope and intensity probably can best be started in phases. Phasing the program in over two or three years would allow experience and momentum to build. It would also improve the chances that the program becomes a lasting success. There will be problems, and even some failures along the way. Moving in phases provides an opportunity to work out problems as they develop, and benefit from the solutions in later phases. Trained staff with experience gained in early phases will be a rich resource for beginning the later phases.

6.2.2 Structuring for Forecasting

The responsibility for all functions from sampling to making forecasts needs to be placed with the governorate offices. This would require decentralizing some responsibilities and restructuring the offices along functional lines. The DOS would retain full responsibility for national coordination and oversight. Such an alignment would optimize utilization of staff and workflow. Staff could be trained in specific operations, and through experience, develop a high level of expertise. The plan outlined in Section 6.5 provides the needed training to prepare staff to carryout the full range of duties. Crop forecasting schedules operate on a very tight time schedule and many operations must be going on simultaneously. Offices organized by function would be more able to respond to the tight time schedules.

Following a national calendar showing the dates various forecasts are needed, the DOS would prepare the survey schedule for meeting the dates. All operations from selecting the survey sample to making the forecast would be done in the governorate offices. To prepare staff to assume this added responsibility, the proposed training program needs to be started very soon.

The number of laboratories will need to be increased from the two now in operation to four or five. Regional laboratories are preferable to having a lab in each governorate for several reasons. Fewer labs mean less equipment is needed. With fewer labs to furnish, more and better equipment can be provided for the regional labs. Training for lab technicians can be concentrated on fewer people. Fewer technicians handling the lab work should result in higher-quality work. A disadvantage of regional labs is the need to transport field samples to another governorate.

The regional field supervisors used during the study were very effective in their role as trainers and coordinators. They provided valuable one-on-one instruction and kept the work moving. Although there is no prevision for such a position in the MALR organization, regional supervisors would be a great addition to the DOS staff to assist with forecasting surveys.

6.3 Operating the System for Forecasting

This section summarizes the major operations necessary to operate and manage the new system. The steps from survey design to making the forecast must be carried out sequentially. The operations are presented in the order they need to be initiated. However, several operations may be active simultaneously at various times during the survey period. Detailed operational procedures are in the Annex.

6.3.1 Data Requirements

The desired output from the system will determine the data needed to drive the program. The date needed in the first forecast and the number of forecasts to be made should be determined before designing the work plan and its implementation.

It is known that forecasting uses both historic data and current data to produce future data. Historic data come from a database of previous survey results. Current data are the results of counts and measurements to assess present conditions. The two are used together to produce forecasts. Hence, establishing the database for annual survey data is very essential.

6.3.2 Sampling Technique

The geographic level and precision of the forecasts determine the sample size. First, the level of the forecast must be determined (district, governorate, national). Next one needs to know the desired precision (standard error) of the forecasts desired. Using these factors, and any knowledge about the variance of the sampling units, the optimum sample size can be determined. Sample size needs to be determined early enough to allow for preparing adequate survey materials. The team estimates that reliable forecasts can be made at the national level with a sample of 200 - 300 fields. Governorate-level forecasts would require 60 - 80 sample fields.

In the past, forecasting survey samples have been selected as a sub-set of the crop-cutting sample. Applying the crop cutting sampling procedure in its pure form results in larger samples than are needed for forecasting. A sampling procedure needs to be designed specifically for forecasting.

The results of wheat yield forecasting in 2000 provide guidance for planning future surveys. The analysis of variance of plot measurements, especially yields, can be utilized for determining the total number of plots needed to estimate the mean yield with a given accuracy. This can be done with the help of the following formula:

$$SE\% = \frac{\frac{s}{\sqrt{n}}}{\bar{x}} * 100$$

Where SE% is the standard error percentage of the estimate, n is the total number of plots used, O is the total average plot yield or other plot measurements and s is the standard deviation of the estimate.
This equation can be written as:

s^2

$$n = \frac{\qquad}{(SE\%)^2\ \bar{x}^2} * 100^2$$

From this formula we can calculate sample size at different levels of standard error percentages (SE%) (1,2,3,4,5) as follows:

Sample size for kernel weight per plot

$$n = \frac{(95.83)^2}{(SE\%)^2\ (254.2)^2} * 100^2$$

Sample size for head number per plot

$$n = \frac{(37.42)^2}{(SE\%)^2\ (131.9)} * 100^2$$

Sample size for average head weight

$$n = \frac{(0.604)^2}{(0.057)^2\ (1.889)^2} * 100^2$$

Table 6-1: Sample Size for Different Levels of Precision

S.E. %	Number of Plots Needed for forecasting		
	Average Weight of Kernels/Plot	**Average Head number/Plot**	**Average Weight of Head (Kernels)**
1	1527	1022	808
2	382	256	202
3	170	114	90
4	95	64	51
5	61	61	33

Table 6-1 shows that about 170 plots are neededd to estimate the average weight of kernels per plot (60 cm x 60 cm), about 114 plots to estimate number of heads per plot, and about 90 plots to estimate kernel weight per head at the 3% level of precision.
The pooled analysis of variance of plot yields can be utilized for determining the number of clusters (or primary sampling units) which have to be sampled for a given number of fields within cluster, and for a given number of plots per field to estimate the mean yield within a given precision.

This can be done by applying the following formula:

$$V(\bar{Y}) = \frac{C}{n} + \frac{F}{mn} + \frac{P}{nml}$$

Where V(Y) is the variance of the estimated average yield of the tract, n is the total number of clusters selected, m is the number of fields selected in each cluster, l is the number of plots in each field, and C, F, and P are the true variance components estimated "between cluster", "between fields", and "between plots" respectively, and n is distributed among the strata in proportion to the area under the wheat crop.

6.3.3 Whether to Use More than One Plot per Field

To answer the question of whether to use one or two plots within a field, Table 6-4 shows the comparison of sample means of paired observations for plots 1 and 2 within a field. The null hypothesis tested is that the mean of the population of differences is zero; the alternative is that the mean is not zero. The test criterion is distributed as t when the assumption that differences are normally distributed is correct and the null hypothesis is true.

The results could be summarized as follows:

Number of spikes per plot (56 pairs)		
Average of	plot (1) = 130.8	plot (2) = 132.5
Standard error %	plot (1) = 3.7%	plot (2) = 4.0%
t calculated 0.28 for 55 df		

Here the observed difference is explained on the basis of random sampling from the population associated with the null hypothesis. The null hypothesis is not rejected on the basis of the evidence presented. In other word, there is no significant difference between observations of plots 1 and 2 within a field.

Average yield/plot (12.5% moisture)		
Average yield	plot (1) = 235.6 gm	plot (2) = 253.2 gm
Standard error %	plot (1) = 4.9	plot (2) = 5.5
t calculated 1.69 for 55 df		

Table 6-2: Number of Heads per Plot Within the Field and it's difference

	Number of Heads /plot		Different	Yield /plot gm Weight 12.5% Moisture		Different
	Plot 1	Plot 2		Plot 1	Plot 2	
1	142	172	-30	205.60	261.37	-55.77
2	176	153	23	277.26	241.49	35.77
3	97	63	34	220.34	128.69	91.66
4	130	155	-25	125.71	193.14	-67.43
5	93	105	-12	150.74	203.20	-52.46
6	101	143	-42	86.29	210.40	-124.11
7	57	93	-36	87.09	155.20	-68.11
8	130	121	9	218.06	152.46	65.60
9	114	193	-79	176.00	178.29	-2.29
10	130	136	-6	217.14	254.40	-37.26
11	110	136	-26	171.31	137.60	33.71
12	116	65	51	247.09	152.69	94.40
13	98	189	-91	219.43	249.37	-29.94
14	145	145	0	89.71	155.43	-65.71
15	93	76	17	182.86	128.91	53.94
16	121	122	-1	212.11	175.89	36.23
17	126	120	6	248.46	218.06	30.40
18	90	84	6	190.17	160.91	29.26
19	70	105	-35	186.63	217.14	-30.51
20	124	117	7	277.26	297.83	-20.57
21	109	126	-17	219.20	295.66	-76.46
22	198	154	44	109.83	185.14	-75.31
23	103	149	-46	185.94	299.66	-113.71
24	196	166	30	275.20	259.54	15.66
25	87	55	32	10.40	87.09	-76.69
26	105	116	-11	219.43	174.63	44.80
27	157	138	19	327.66	204.23	123.43
28	111	98	13	234.86	167.43	67.43
29	227	157	70	353.94	395.09	-41.14
30	138	100	38	242.29	162.40	79.89
31	155	145	10	261.60	185.37	76.23
32	186	133	53	277.49	292.11	-14.63
33	146	153	-7	214.97	322.29	-107.31
34	113	108	5	260.69	228.91	31.77
35	172	135	37	268.80	279.43	-10.63
36	100	70	30	227.31	147.43	79.89
37	96	189	-93	195.20	261.94	-66.74
38	134	142	-8	222.97	249.94	-26.97
39	159	138	21	335.66	264.34	71.31
40	177	112	65	329.49	194.06	135.43
41	109	103	6	261.37	257.94	3.43
42	162	134	28	404.00	381.26	22.74
43	184	207	-23	250.40	421.94	-171.54
44	118	183	-65	294.63	412.80	-118.17
45	118	143	-25	409.14	505.71	-96.57
46	109	103	6	294.06	298.51	-4.46
47	80	124	-44	235.66	350.29	-114.63
48	143	209	-66	305.94	462.51	-156.57
49	159	126	33	385.37	287.54	97.83
50	169	195	-26	406.97	582.06	-175.09
51	123	128	-5	250.40	329.14	-78.74
52	145	98	47	346.29	327.20	19.09
53	134	65	69	72.11	79.54	-7.43
54	94	242	-148	95.09	234.51	-139.43
55	191	147	44	326.06	416.80	-90.74
56	157	133	24	294.74	299.77	-5.03

Table 6-3: Descriptive Analysis for the Difference Between Plot One and Two

	Number of Heads /plot			Yield /plot gm Weight 12.5% Moisture		
	Plot 1	Plot 2	Difference	Plot 1	Plot 2	Difference
Mean	130.8392857	132.4464286	-1.607142857	235.6142857	253.155102	-17.54081633
Standard Error	4.774375378	5.282408913	5.794515912	11.65978164	13.88200678	10.36316132
Median	125	133.5	6	235.2571429	245.4285714	-12.62857143
Mode	130	153	6	277.2571429	#N/A	#N/A
Standard Deviation	35.7281538	39.52992866	43.36218653	87.25381618	103.8834264	77.55079821
Sample Variance	1276.500974	1562.61526	1880.279221	7613.228438	10791.76629	6014.126304
Kurtosis	-0.157883514	0.245253528	1.369643103	0.12956126	1.002836873	-0.752161651
Skewness	0.458481405	0.319676539	-0.918858707	-0.205137896	0.949577286	-0.097449791
Range	170	187	218	398.7428571	502.5142857	310.5142857
Minimum	57	55	-148	10.4	79.54285714	-175.0857143
Maximum	227	242	70	409.1428571	582.0571429	135.4285714
Sum	7327	7417	-90	13194.4	14176.68571	-982.2857143
Count	56	56	56	56	56	56

Table 6-4a: t-Test in Pairs for the Number of Heads/plot (1) and (2) Within the Field

t-Test: Paired Two Sample for Means

	Variable 1	*Variable 2*
Mean	130.8392857	132.4464286
Variance	1276.500974	1562.61526
Observations	56	56
Pearson Correlation	0.339451857	
Hypothesized Mean	0	
df	55	
t Stat	-0.277355845	
P(T<=t) one-tail	0.391273363	
t Critical one-tail	1.673033694	
P(T<=t) two-tail	0.782546726	
t Critical two-tail	2.004044291	

Table 6-4b: t-Test in Pairs for the Wheat Yield per plot (1) and (2) Within the Field

t-Test: Paired Two Sample for Means

	Plot 1	*Plot 2*
Mean	235.6142857	253.155102
Variance	7613.228438	10791.76629
Observations	56	56
Pearson Correlatio	0.683503989	
Hypothesized Mea	0	
df	55	
t Stat	-1.692612494	
P(T<=t) one-tail	0.048093678	
t Critical one-tail	1.673033694	
P(T<=t) two-tail	0.096187357	
t Critical two-tail	2.004044291	

The difference between the two plots in average is still insignificant.

For the whole sample	113 plots
Average yield/plot	245.17 gm.
S.E %	3.17%

Therefore, the use of one plot or two plots within field has to be discussed on the basis of both cost and accuracy of the survey. This issue needs more investigation and research.

6.3.4 Pre-Survey Preparation

Proper pre-survey preparation is the first step in an efficient and successful survey operation. Planning for next year's survey ought to start as soon as the current year 's survey ends. The first thing that should be done is to update the historic databases with the current year's data. This preserves the data for future use and guards against accidental loss. The best time to check the condition of equipment is when the current survey ends and before it is stored to be used next year. If broken or unusable equipment is stored, it will still be in the same condition when taken out of storage. Repairing and inventorying all equipment before it is stored prevents a last-minute rush to get enough equipment together to start the next survey. Having all of the equipment and supplies ready before the survey starts sets the stage for the entire survey. Every enumerator team needs a complete set of field equipment, and extra equipment should be held in reserve because items will break or be lost during the fieldwork. Laboratory scales and balances should be checked for accuracy and repaired or replaced if it need to be.

Adequate supplies are a necessity for enumerators to do high-quality work. Budgeting for expendable items is always difficult, but it must be done. Cutting corners on survey supplies always results in substandard work. Every enumerator should have a complete and current survey manual. The manuals need to be covered in detail during the pre-survey training.

Although training is an ongoing need, and should be done throughout the survey cycle, it is discussed here because pre-survey training is of primary importance. There is no substitute for a well-trained staff. Training, like quality control, is an added expense, and sometimes is cut back for budgetary reasons. When this happens, data quality suffers. If training is de-emphasized over a long period of time, survey results may become uncertain and suspect. Survey-specific training should be coordinated through the DOS to assure nationwide consistency, and needs to be considered a necessary part of the survey process.

Pre-survey training can be effectively done in two ways, both of which ensure consistency across all governorates. One way is to train the trainers and have them train the sampling office staff. Key people from each governorate would be trained in survey procedures and operation. They would go back to their governorates and train the field and lab staff to do the survey work. This method has the potential to produce the greatest long-term benefit to the sampling offices. It develops training skills at the local level and enriches the staff with the knowledge to solve operational problems.

The second method is to bring field enumerators and lab technicians together in groups for training conducted by a select training staff. The training staff would be made up of DOS personnel and perhaps some highly skilled people from the governorate offices. The field and lab staffs from a single office, or a group of offices, would be brought together for training and return to their offices prepared to begin the survey work. The same training staff would do all of the training at the various locations. This method allows greater control over the training process and assures a higher degree of consistency across the governorates. The study team used this method and found it to be very effective. It could be used for one or two years to develop the expertise to rely more heavily on the local staff for training.

Another pre-survey activity is to be sure that adequate transportation is available to complete the fieldwork within the scheduled time frame.

6.3.5 Data Collection

The time frame established during pre-survey planning for each data collection needs to be adhered to following clearly documented procedures. Instruction manuals, reporting forms, and supervision guide the data collection process. Training and supervision assure that the procedures used in all governorates are consistent.

Data collection is a stepwise process that begins with laying out the field plots and continues until the sample fields are harvested. Regardless of when the first forecast is needed, the plots should be laid out before plant stem elongation starts. Plots can be more accurately established with less damage to plants in the plots and surrounding area at this stage of growth. Normally stem elongation begins in late January. The plot must be securely established, including all divisions for future counting and clipping activities. This helps to prevent unnecessary damage to plants on return visits

Recording forms to be used on each field visit should be prepared in the office before going to the field. All of the ID information should be entered on the forms before leaving the office. A Form A and a Form B will be needed on the first visit. On return visits, a Form B, Form C-1 or C-2, ID Tags and paper bag will be needed depending on the maturity stage of the plots. Assemble all supplies to be used into a packet in the office. If there is uncertainty about which Form C will be needed, have both available and add the appropriate one to the form set after reaching the field. Working conditions in the office are better for preparing the forms than in the field. Having the forms prepared beforehand saves valuable time in the field. It also reduces the chance of recording errors. Carry the forms into the field and record counts and measurements directly on the forms. Recording counts and measurement on material other than the forms and copying it to the forms later increases the chance of recording errors. A clipboard or clear plastic folder would be a good addition to help enumerators organize and protect their forms.

All bags containing plant samples to be sent to the laboratory must be securely closed to prevent heads from spilling out. Attach all bags, along with the appropriate ID tags, together for sending to the laboratory. Forms are sent to the designated office for processing (see all of the forms in annex D).

6.3.6 Data Review, Processing and Analysis

The first step in data processing is a careful check and review of all forms as they are received in the office from the field. This process can start as soon as the first forms are received. Reviewing and editing field reports is very important to maintain consistency. However, over editing can introduce bias into the survey results. Data reviewers need to keep several things in mind when reviewing field data. First, the purpose of editing should always be to get a high-qualitydata. Second, forecasting plots are very small and small errors can have big affect on survey results. Third, field enumerators work under difficult conditions and sometimes make recording errors. Fourth, reviewers have access to previous counts and measurements from the plots to use as a guide. Additionally, the review process should be done in the governorate offices to take advantage of the staff's knowledge about local conditions. Reviewing and editing is a group activity. Reviewers must work closely with field enumerators to resolve questionable items. Enumerator's notes on the forms often explain unusual circumstances that may cause the data to appear out of line.

Editing guides need to be developed and followed when reviewing field data. Documented guidelines help analysts to maintain consistency. Some examples of checks that can be made from visit to visit are: maturity stage, number of stalks and number of fruit at various stages of development. Maximum/minimum values for data items can be used to screen for recording errors. If the data are computerized the data entry program can do much of the editing, but forms should be carefully reviewed before entry. After all individual reports are clean, the data set is summarized to the governorate and national levels, and the review process continues.

Summarized data also need to be carefully reviewed. Frequency distributions to check for outlines, ratios to evaluate reasonableness and comparisons with previous months and years are some ways to check summaries. Data validation cannot be over emphasized. When averages or ratios appear to be outside expectations, check for possible causes. For example, low head weight could be the result of cool temperatures during pollination that caused excessive sterile spikelets. Serious outbreaks of disease may reduce the number and size of kernels, thereby, reducing head weight. Governorate staff would be more likely than headquarters staff to be aware of such conditions. This is one reason data needs to be summarized and reviewed at the local level.

Data analysis looks at various relationships within the summarized data set. This procedure is best done by computer, but can be done by hand if necessary. Some dependent relationships are: maturity stage/ number of fruit (early boot, late boot, and emerged heads) and number of stalks/ number of heads. Analysis also looks at the conditions that affect the data set in various ways.

6.3.7 Computing Forecasts

The forecasting models should be executed only after the data are properly reviewed, edited and analyzed. Review and analysis should continue even after the forecasts are computed. The items being forecasted are the components of yield. After the forecasted components are reviewed, the yield is computed. The form of the forecasting models is shown in Chapter 3 and the execution of the models is illustrated in Chapter 5.

6.3.8 Storing and Preserving Survey Data

The dataset from each survey is a valuable component of the historic database and should be treated with great care. Averages based on at least three years, and preferably five years, of survey data are needed for computing the early-season forecasts. After five years of data are available, the historic data should be based on a five-year rolling average. When each survey is finished, compute new historic averages by dropping the sixth previous year, and adding the most recent year.

6.4 Supervision, Quality Control and Evaluation

Quality control is one for the most important aspects of the survey process. A clearly documented program of quality control must be established and carried out through effective supervision. The methods and procedures need to be constantly monitored and evaluated. A good system will rapidly deteriorate from neglect if it is not maintained.

6.4.1 Supervision and Quality Control

Supervisors need to have a full technical understanding of the work as well as skills in teaching and training. Quality control is necessary to maintain high data standards and should not be viewed as simply a procedure for pointing out errors and mistakes. When budgets get tight, quality control is often the first activity to be cut back or eliminated. This should never happen. If the quality and integrity of the survey results can't be maintained, the data may become misleading or even worthless.

Supervisors can monitor procedures by accompanying enumerators on their routine field visits. This is especially helpful early in the survey cycle and for inexperienced enumerators. One-on-one observation and training is a good way to assure that proper procedures are being followed and to correct any errors. Supervisors also ought to follow behind the enumerator by going to the sample field and completing the same activities as the enumerator. It is preferable that the supervisor visit is on the same day as the enumerator visit, but should always be done within two days. This is an effective way to check accuracy of counting, proper determination of maturity stage and the like.

Laboratory procedures and performance need to be monitored in the same manner as the fieldwork. Supervisors should work alongside lab technicians to determine if proper procedures are being used and to provide one-on-one training. Supervisors can check accuracy of the technician's work by the repeating counts, measurements and weighings made by the technicians.

6.4.2 Non-Sampling Error

The quality control procedures described in Section 6.4.1 are necessary to reduce non-sampling error. Some human error will always be present, but it can be minimized by carefully following procedures and a strict program of supervision and quality control. The small plots are subject to large non-sampling errors if proper procedures are not followed. The loss of, or erroneous inclusion of, one head represents about 24 kg per feddan. Seven heads amount to about one ardab per feddan.

6.4.3 Sampling Error

The source of sampling error is variation among the sampling units in the population being measured, and is commonly expressed as Standard Error or % S.E. Stratification of the population into homogeneous groups before sampling is the most effective way to reduce sampling error. Increasing the sample size is another way to reduce sampling error, but has serious implications. Cost is a major consideration because generally a four-fold increase in sample size is required to cut the sampling error in half. There is also a direct relationship between sample size and non-sampling error. As the sample size is increased, non-sampling error also goes up. Keeping sample size at the minimum allows for closer supervision and monitoring, making it easier to control non-sampling error.

6.4.4 Evaluating Forecasts

The types of error discussed above can be used to evaluate forecasts, but the real proof is how the forecasts relate to the final estimate. Evaluating forecasts in relation to the final estimate must consider several factors. Forecasts, especially very early in the season, are based to a large degree on historic databases. When one or more of the components of yield is greatly different at harvest than the historic average, final yield will differ from the forecasts. Usually the reason for the difference is readily apparent. Factors like cold temperatures during pollination, a sudden onset of hot weather before wheat ripens and outbreaks of disease or insects may suddenly change the yield potential of a crop and contribute to the differences.

6.5 Resource Requirements

Adding yield forecasting to the wheat-estimating program will be costly. The scope of the program should be limited to a size that can be properly funded and maintained. Only through adequate support can forecasts maintain their integrity as a reliable indicators of final yield.

6.5.1 Staff

The number of staff in DOS and the governorate offices is probably adequate to absorb the additional work, but training and restructuring of assignments will be needed to prepare the staff for crop forecasting. Training in both basic statistical methodology and survey operation needs to be emphasized. Training plans are outlined in Section 6.6.

Organizing the staff along functional lines will make it easier to build skills and develop expertise through training and experience. Groups of highly trained people doing several different functions simultaneously will make it easier to meet the tight times schedules of forecasting. This type of organization also provides for individuals to more fully utilize special skills and interests. A brief outline for reassigning responsibilities and restructuring the staff is in Section 6.2.2.

The program already under way in MALR to base salary incentives on the difficulty of job assignments and on performance should be continued. This approach allows highly motivated staff with special skills and interest an opportunity to excel, and will result in increased productivity.

6.5.2 Infrastructure Support

Adequate transportation is one of the most difficult needs to fill in the governorate offices. The demand is seasonal, and it is not feasible to cover the requirements for peak periods of use. However, arrangements must be made for enumerators to complete all assigned work during the survey period. Hiring cars during times of peak workload is a common practice in some offices, but can be a strain on already tight budgets. If engineers own a vehicle, reimbursing them for its use is a practical way to provide transportation. Maintenance of MALR-owned vehicles is usually low on the list of priorities; consequently, many are in poor condition. Providing motorcycles to engineers and allowing them to be purchased over a long period of time could help solve both the problem of availability and maintenance.

Laboratory and office equipment needs to be upgraded. The equipment in the two laboratories is barely adequate to meet minimum needs. The electronic balances carried over from the mid-80's project need to be checked for accuracy and repaired or replaced if need to be. MALR is planning to get moisture meters for the labs. This will speed up the processing of samples. Laboratory threshers would greatly increase the labs' capacity to process the final harvest samples. Threshers are a major investment but will last for many years.

Office equipment such as calculators and adding machines are needed to improve accuracy and workflow. Even with adequate hand-operated equipment, it would be impracticable to process the forecast survey data by hand. At least some of the governorate offices need to be equipped with computers.

The ideal situation would be to place computers in all offices, but if that can't be done, regional processing centers should be set up. One office could process the data for one or more other offices. Forms could either be sent to their home office for review and editing and then to the processing center, or sent directly to the processing center. Either method would require close cooperation between the offices to keep the work moving and to assure that adequate review and analysis is done.

6.5.3 Supplies

Minimum standards should be established for field supplies. This would serve as a guide for local offices to be sure that the items they procured are adequate. Items to complete the field and office work must be available when needed. Reporting forms are a basic requirement and must be available on time and in sufficient quantities to complete the field and laboratory work.

6.6 Skills Training

This three-part program is designed to provide training for staff in statistical organizations, with emphasis on MALR, and to introduce data users to statistics as a valuable tool for planning and decision-making. The statistics component includes four courses and will equip staff in statistics offices to design surveys; select samples; train data collectors; collect, process and analyze data; make estimates and submit them to higher levels. Course 4 is for mangers and decision makers. The objective yield component has four courses in advanced training in applied objective yield survey design and operation. The agronomic component is training in wheat plant characteristics and growth habits. The later two components are primarily for survey field enumerators and laboratory staff. The applied statistics courses in the first component would be useful to anyone involved in statistics work, including district and village level officers.

The advanced training in objective yield survey design and operation is for agricultural engineers with responsibility for wheat yield surveys. Although the design concepts of all objective surveys bear some similarity, the operational procedures are crop-specific. The statistics courses cover the design concepts and operational methodology of various types of surveys in a general way. These courses focus specifically on wheat surveys.

The agronomic training is designed to give field staff a better understanding of basic plant physiology, growth habits developmental stages and factors affecting productivity. All agricultural engineers involved in survey field and laboratory work should complete this training.

6.6.1 Statistics Component

The four statistics courses are designed to provide general training in applied agricultural statistics. Although each course is a unit, they should be taken in sequence. All existing staff in MALR with responsibility for statistical program support should complete statistics courses 1, 2 and 3. Course 4 is for managers and policy makers. New employees should be enrolled in the courses as soon as feasible after coming on board.

Instructions include classroom lectures, discussions, exercises and field trips for demonstrations and observations. Courses 1 and 3 can each be completed in 25 hours; course 2 requires 50 hours; and course 4 is designed for 10 hours. Table G1-G5 show details of the subject matter covered in each course.

Course 1, Introduction to Statistics - Reviews the current system for collecting and disseminating statistics with emphasis on agricultural statistics. Review different kinds of surveys and their requirements and uses. Looks at the changing needs for statistics and the role of governments in meeting the need.

Course 2, Sampling and Methods of Statistics - Covers the principles and methods of survey design, sampling; data collection, processing, analysis, review and dissemination; and data quality.

Course 3, Operation of Statistical Systems - Applies the principles and methods of course two to design and develop operational plans for a demonstration survey.

Course 4, Data Needs, Uses and Standards - Reviews statistical systems, coordination and standards; statistics as a decision making tool; and, the impact of accurate or (inaccurate) statistics on government and private sector decision-making.

6.6.2 Objective Yield Survey Procedures Component

The objective yield survey procedures component includes four courses. Courses 1, 2 and 3 target specific groups of the staffs working with objective yield surveys. Course 4 is advanced training for staff responsible for analyzing survey data and making forecasts and estimates based on the data. There is some overlap of subject matter between this component and the statistics courses outlined above. The statistics courses treat the subject matter in a general way, and this component focuses narrowly on objective yield survey applications. These courses do not eliminate the need for annual objective yield survey training, but could reduce the length and intensity of the annual survey training. See Tables G1-G5 for details of the subject matter covered by these courses.

Course 1 and course 4 require 8 hours each for completion. Courses 2 and 3 can each be completed in 16 hours.

Course 1, for Enumerators - This course is for all field enumerators and supervisors. It is also recommended for engineers responsible for the survey laboratory activities and data analysts.

Course 2, for Field Supervisors - Requisite, Course 1. Covers supervisor responsibilities, controlling non-sampling error, and report writing. Reviews agriculture policy that needs reliable and timely statistics for informed decision-making.

Course 3, for Laboratory Staff and Field Supervisors - In addition to laboratory procedures and equipment, this course covers the importance of accuracy and special counts and measurements for yield forecasting research.

Course 4, for Data Analysts - Requisite, Course 1, 2 or 3 (preferably all three), reviews different sampling methods and covers the principle steps in the methods used for selecting samples for forecasting surveys. Covers data review and analysis, the different estimators (indications) that can be computed from the survey data, sources of sampling and non-sampling error, and making forecasts and estimates from survey data.

6.6.3 Agronomic Component

The purpose of this kind of training is to instruct field enumerators and laboratory technicians about plant characteristics and growth habits. Much of the training needed in this area can be accomplished through participation in regularly scheduled field days at agricultural research stations. Research stations conduct field days several times each year to showcase the results of their research and plant breeding programs. Through these sessions, the new technology is transferred to the production level through the agricultural extension agents. Information on new varieties, cultural methods, enhancements and constraints to productivity, and other changes is disseminated at these field days. By taking part in this program, MALR agricultural engineers can increase their knowledge of plant culture and stay abreast of changes in varieties being grown and agricultural practices. Additional crop-specific training on growth habits and plant development stages can be arranged through the research stations to complement the survey procedures training for objective surveys.

Wheat researchers from the agricultural research stations were a valuable asset for training field people for the study. They should be made a regular part of the annual survey-training program.

The intensity of this kind of training can be reduced as the staffs become knowledgeable about plant characteristics and growth habits, but will never disappear completely. New employees need the training and all agricultural engineers responsible for survey field and laboratory work need periodic refresher courses.

7. MAIN FINDINGS AND RECOMMENDATIONS

This study focused on wheat yield forecasting. The main objectives were to: 1) Assess the quality of wheat yield forecasts being made in the MALR, and 2) Recommend the appropriate method of wheat yield forecasting to be adopted by the MALR. The basis for assessing the existing system was interviews with governorate sampling office staff, farmers, extension agents and others; and the review of previous study documents. The recommendation of the methodology to be adopted is based mainly on the results of the field tests conducted in this study. Previous work and research studies on forecasting were also considered.

The structure and operation of the study was unique in several ways. Cost and oversight were shared between MALR and MVE, and agricultural experiment station researchers provided technical guidance.

MALR gave strong support at all level of its organization, and underwrote the operational costs including training, transportation and salary incentives. The Director of Sampling, the Undersecretary of the CAAE, and the First Undersecretary of EAS were prominent in their endorsement and support during the study. The DOS provided strong coordination and oversight. The governorate sampling offices are commended for their dedication to making the study a success. They worked on their scheduled days off many times during the monthly field visits, and sometimes spent 10 hours or more a day in the field.

The cooperation between MALR and the wheat researchers at the agricultural experiment stations was one of the most unique and beneficial aspects of the study. Agronomists and plant breeders participated in the training and fieldwork each month. They shared valuable insights about plant characteristics and factors affecting production.

The MVE Unit provided the study team and did the data processing and analysis.

7.1 Main Findings - Existing System

Although past attempts at yield forecasting were short lived, the time seems right to begin such a program on a national scale.

7.1.1 Sampling Procedures

Two methods are used to determine wheat cultivated area. Extension agents do a complete enumeration of wheat fields. The second method uses a 50% sample of area clusters. The optimum sample size for crop-cutting is computed from the previous year survey results. The total sample size is unnecessarily large due to the large number of strata in the sampling frame and included 5124 fields in year 2000. The survey results returned a Standard Error of about 0.5% at the national level

7.1.2 Data Collection, Processing and Review

Data collection for area and crop-cutting surveys is a lengthy and labor-intensive process and produces large volumes of data to be handled. Processing is done by hand and review and checking procedures are inconsistent. Frequent and sometimes large changes are made in the estimates as they move to higher levels. As the review moves further away from the data source, changes likely reduce accuracy. Changes usually raise the estimates. This may be partially due to an upward bias from rewards offered for achieving high yields or meeting target levels.

7.1.3 Quality and Timeliness of Estimates

Area estimates at the village level are thought to be accurate. The single annual yield estimate, based on crop cutting surveys, is made in the governorates at the district level and forwarded to EAS. The large sample size should support accuracy, but field procedures observed during the study indicate that crop cutting survey data could include large non-sampling errors. Estimates are available too late to be of maximum benefit to data users. The area estimate usually is published in May and the yield estimate is available several weeks after harvest is finished.

7.1.4 Data Needs

Privatization of the Agricultural Sector, and moves toward a market driven economy, are creating needs for statistics that the current system cannot supply. Farmers, managers and policy makers need reliable and timely statistics on wheat production to participate more competitively in domestic and world markets.

7.1.5 Training

MALR staff is generally under trained and are doing work at all levels for which they are not trained. Many engineers with long service records have had little or no training in applied sampling and survey methodology. As new engineers come on board, their only training is “on the job”. This is a sound concept but it is not effective because of the low skills and knowledge level of existing employees, and perpetuates any erroneous practices and procedures. The MALR needs to develop an in-service training program for agricultural engineers at the governorate level.

7.1.6 Equipment, Supplies and Support

Transportation, field equipment, office equipment and availability of office supplies need to be upgraded. A shortage of adequate transportation delays the completion of fieldwork. Much of the survey equipment is old, in poor condition and heavy to carry to the field, especially if the enumerator is traveling by motorcycle. Office equipment is almost nonexistent in most offices. Items such as calculators and adding machines could greatly improve accuracy and work flow.

7.2 Main Findings- Proposed System

- Work in the mid-1980s, and research at the AERI since that time, indicated that the objective yield crop forecasting method is appropriate for Egypt. The results of this study show that yields can be accurately forecasted from small plot data early in the season.

- There is no program for forecasting wheat yield before harvest. All wheat forecasting activities ended in 1998.

- Eventhough this study was not suppose to produce reliable forecasts of yield, but the results obtained by this study for yield forecasting was statistically accepted and as reliable as the crop-cutting experiments results

- Governorate sampling office staff demonstrated the willingness to learn the new method and the abilities to carry out the survey procedures when properly equipped and trained.

- Researchers from the agricultural experiment stations provided valuable training in the characteristics and growth habits of wheat and factors that affect productivity. Their assistance prepared field enumerators to better understand and interpret condition they saw in the field. The researchers also provided helpful insights into factors that need to be researched in the future as possible indicators of potential yield.

Results show that forecasts can be made as early as the end of January to reliably project final yield. However, forecasts become more reliable as the crop advances toward maturity.

7.2.1 Yield Forecasting Technique

Reliable early season forecasts for wheat yield would fill a large void in the available statistics.

- EAS has shown a renewed interest in pre-harvest forecasting as a way to improve statisticon wheat and this study was made possible through its support.

- Strong organization, proper equipment and supplies, intensive training, and close supervision and quality control are necessary to assure high quality survey results.

7.3 Recommendations

The recommendations are listed in priority order from highest to lowest. Although one of the main objectives of the study was to recommend a new method for forecasting yield, that recommendation is listed second to the recommendation for training. There are several reasons for this arrangement of the recommendations. First, forecasting requires a high level of technical expertise, which is not now present in the MALR. Second, governorate staff recognizes their need for training. Third, a willingness to invest in educating the staff would demonstrate a commitment to the program by top management. Fourth, a well-trained staff will boost the confidence that data users place in the forecasts. In practice, the first three recommendations are all critical to a successful forecasting program.

7.3.1 Initiate a Comprehensive Training Program

One of the most persistent comments heard from staff in the governorate sampling offices concerned the lack of, and need for, training. The proposed training program in Chapter 6 is designed for personnel in all statistical organization, but focuses on the needs of MALR. It includes general training in applied agricultural statistics and specific courses on objective survey operational procedures for selected groups of employees based on their area of responsibility. One course is to help managers and policy makers better understand the need for, and uses of, statistics.

7.3.2 Adopt Objective Methods For Pre-Harvest Forecasting of Wheat Yield

Objective methods are used successfully in other countries to forecast crop yields before harvest. The methodology and procedures are valid for Egypt and should be adopted all over the country as the main indicator of pre-harvest yield levels for wheat. The forecasts do not replace final estimates from crop cutting surveys, but enhance their usefulness.

7.3.3 Structure MALR For Crop Forecasting

The restructured governorate offices would assume some functions now done by the DOS. Restructuring places new responsibilities on both the DOS and the governorate offices. The DOS role becomes one of coordinating and managing the nationwide system as it shifts away from the details of doing the work.

New responsibilities added to the governorate office include functions like sample selection, data review and processing and setting and submitting estimates. Under this kind of organization, staff can develop expertise in specific functions and be more effective in doing their jobs.

- **Organize and train staff for specific functions.** Many functions must be going on simultaneously to meet the tight time schedule from pre-survey planning to release of the forecasts. Offices need to be organized to handle the workflow, and staff trained in specific operational procedures. The DOS staff would have responsibility for, and be equipped, for training the governorate personnel.

- **Establish survey schedules and release dates.** Demands from data users should drive the program. Set dates for public release of forecasts and develop the survey schedule to support those dates.

- **Select samples at the governorate level.** Each governorate is a domain in the sampling process. Governorate staff should be trained to compute optimum sample sizes and select the samples to derive maximum benefit from their knowledge of local conditions.

- **Equip governorate offices with computers.** Large amounts of data must be processed in short periods to support objective forecasting. Execution of the forecasting models requires relating current survey data to large historic databases. It would be impracticable, if not impossible, to make these calculations by hand in a timely manner. Setting up regional data processing centers is an alternative to placing computers in all offices. However, the best possible situation would be for each governorate to do its own data processing, and this should be the long-term goal.

- **Enter, review and analyze survey data, and make estimates in the governorate offices.** The restructured governorate offices will be capable of completing all functions from sample selection to making estimates when properly trained and equipped. The local staff is in the best position to know about conditions affecting the survey results that need to be considered in the data review and analysis.

- **Publish area estimates** earlier to enhance the value of early season yield forecasts. Both area under wheat and the yield are needed to determine total production.

- **Update existing instruction manuals and prepare new ones where needed**. Operational consistency across survey sites is very important for crop forecasting. The small sample sizes and small plot sizes are subject to high levels of non-sampling error if procedures are not strictly followed.

- **Supervision and quality control.** A strong quality assurance program is necessary to assure that proper procedures are being followed. The regional field supervisors used in the study filled a vital role of coordinating the field and lab work and doing quality assurance. This concept should be adopted nationwide for any operational objective surveys. One field supervisor could adequately oversee the field and lab work in two or three governorates. The result would be a better-trained staff, improved workflow, greater accuracy, and ultimately, better data quality.

- **Refine the program for salary incentives.** The MALR has begun a program to base salary incentives on difficulty of engineers' job assignments and level of performance. This program needs to be refined and expanded.

7.3.4 Investigate an Appropriate Sampling Plan For Crop Forecasting

The past practice of selecting forecasting samples as a sub-set of the crop-cutting sample is not adequate. The multistage sampling procedure now being used for crop cutting requires that sample units be allocated to every stratum in the sampling frame. This procedure results in a larger sample than is needed to achieve reliable survey results because of the large number of strata in the existing sampling frame.

7.3.5 Expand and Strengthen Cooperation with Other Government Organizations

The study derived valuable benefits from cooperating with the agricultural research stations on training. The local agricultural extension agents have the best knowledge about local conditions and could help field enumerators locate farmers and fields. The cadastral maps in the agricultural cooperatives could also be used to locate farmers and be of assistance in subdividing selected PSUs and parcels.

7.3.6 Research and Development in Applied Agricultural Statistics

Involve AERI in applied research to refine and develop statistical models and operational procedures. AERI staff should be regular participants in survey training programs and could teach the statistics courses proposed in Chapter 6.

7.3.7 Discontinue Incentives for Achieving Higher Yields or Predetermined Targets

This is a disincentive for accuracy and integrity of estimates and tends to encourage an upward bias.

7.4 Topics for Future Study and Research

Objective yield surveys are a good vehicle for gathering information for research purposes or to address a specific issue at very little added cost. The sample size is small, but statistically valid, and the turnaround time is short. However, care must be taken not to overload the questionnaire to the extent that the survey results are affected. Some specific recommendations follow.

7.4.1 Conduct a Study on the Modeling Response to Long Spike Wheat Varieties

Long-spike varieties are unique for their large number of spikelets, number of grains per head, and high weight per grain among the three genotypes of wheat grown in Egypt. The characteristics of bread wheat and durum varieties are similar and respond in the same way to the forecasting models. However, nothing is known about the response of long-spike varieties, and it needs to be studied.

7.4.2 Calculate the Cost/Benefit Ratio of Crop Forecasting

Forecasting surveys are an added cost to statistics programs. Although adequate benefit to justify their use is assumed, research could compare to cost to the resultant benefits.

7.4.3 Investigate Alternative Modeling Variables

Several plant characteristics e.g. thought to be correlated with one or more of the components of yield were measured during the monthly field visits. These factors need to be studied to determine if any are stable indicators of the components of yield.

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ANNEXES

ANNEX A: WHEAT YIELD FORECASTING TECHNIQUE-THE STATISTICAL BACKGROUND

Wheat Yield Forecasting Technique - The Statistical Background

A. Introduction

Wheat Yield Factors were estimated in five phonological stages namely; pre-flag, early boot or flag or late boot, milk, staff dough, hard and ripe dough stages.

Data were collected on no. of tillers (stalks), flag leaf length and width in addition to no. of tillers (stalks) in flag stage, spike no. in addition to spike weight and its components i.e. kernel no. and kernel weight. Other important characters may be taken into consideration as stem diameter, spike length, spike diameter and plant height in the late booting stage.

These characters are used to build up several models relative to phonological growth stage and/or time. Accuracy and precision of models used is expected to be affected by the time of data collection. Earlier models are less efficient than the late ones. However, earlier models would seem to be more valuable.

In the three early growth stages, data being insufficient oblige the statistician to use historical data for spike yield. Productivity is a function of available yield factors and total production in turn is a function of area and productivity. Modeling is performed in three directories: 1) Within each phonological stage 2) Late booting 3) Over phonological stages.

Data were collected from both count and clip area each 60x60 cm2 to represent ARE wheat area in order to predict total yield production as early as possible. Several governorates were selected to represent varying agro-climatic zones, cultivars, species i.e. T. vulgare and T. durum in addition to agricultural practices, soil types. Experimental fields were randomly chosen and surrounded by flagging ribbons.

<u>Statistical procedure:</u>

Statistical procedure adopted is regression analysis, according to Snedicor and Cachran (1980). The dependent variable (Y) is the total production, yield factors are the independent variables ($X^{'s}$) according to the following model for simple regression.

$$\hat{Y} = a + b_x$$

b = Simple regression coefficient i.e the amount of change in Y when X increases by just one unit ignoring other factors.

For multiple regression it will be:

$$\hat{Y} = a + \sum_{i=}^{k} B_i x_i$$

Where $\hat{Y}$ = Total production
B= Partial simple regression coefficient

i.e. the amount of change in Y due to X_i fixing other factors.

a = Y Intercept = the value of (Y) when (X) equals (∅)
k = no. of factors whether .05 or .01 level of significance is taken into consideration in addition to X_i's ranges, either simple or multiple coefficients of determination i.e. r^2 and R^2 explain the total contribution of yield factors. Within stage simple models evaluation is the first step to be made. Late booting stage model need to apply simple, partial and multiple linear regression and correlation. However, modeling overall stages will be made using stepwise multiple linear regression according to Drape and Smith (1954) to screen variables to the minimum in addition to avoiding multicolenearity expected between alternative factors e.g no. of tillers in pre-flag and flag stages, no. of tillers and no. of spikes, spike no. in milky and dough stage.

Applicability of models in future:

Final analyzed results can not be adopted if one or more of these considerations are ignored.

1- X_i's ranges.
2- B_y/x or b_y/x significance.
3- r^2 or R^2 i.e coefficients of determination.
4- SE i.e. standard error of estimate.

Coefficients of determination measure accuracy i.e. how far our estimate is from the actual value i.e. unity. Standard error of estimates measures the closeness of expected values to observed values i.e. the efficiency of prediction. However, still the models can not be applied in future being misleading.

To avoid misleading and/or to increase both accuracy and precision of model over varying conditions, the criteria must take several steps further via taking macro soil and climate environmental factors. Fortunately, the most important soil factors are water table and salinity and the most important climatic factors are the growing degree-day (temperature) GDD which equals:

$$GDD = [\,(Tmax + Tmin) / 2\,] - Tb$$

Where Tmax and Tmin are the maximum and minimum temperature.

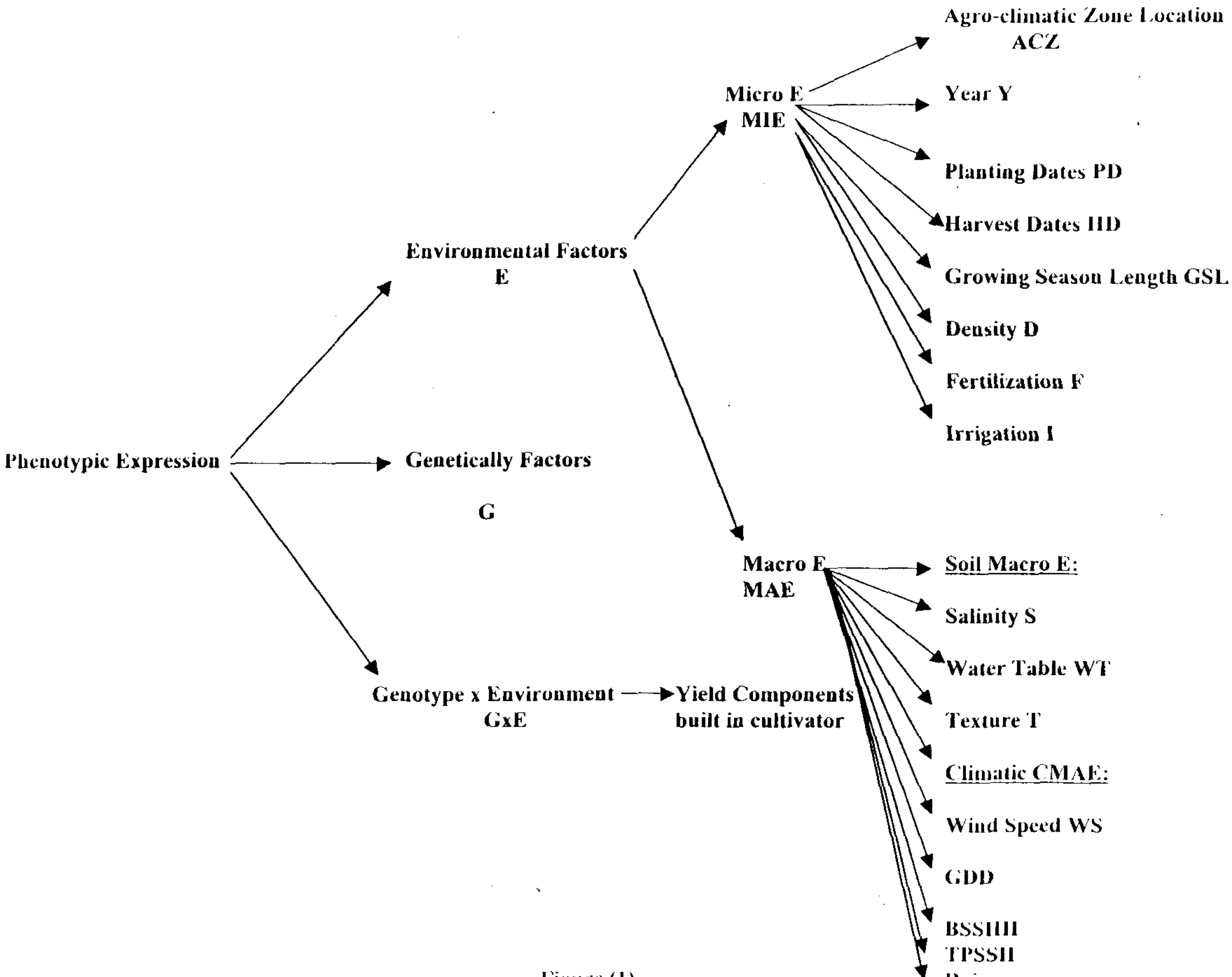
Tb – minimum temperature at which leaf growth cease. It equals about 7°.
In this regard, GDD affects leaf growth, the amount of GDD needed to produce one leaf is known as phillochron, that equals 100°, its magnitude is inversely affected by photo period.

Generally, the model is affected by cultivator, agriculture zone, the time of data collection and/or phonological stage.

Theoretically, modeling may be given in figure (1&2). However, data may be collected on other characters. This will be mentioned later e.g. spike length (LS), spike diameter (SPD), stem diameter (STD), width of flag leaf (FLW), survival ratio percentage (SR%) in addition to available agricultural practices.

Spike length (SL) may be reflected on kernel number (K no.), spike diameter (SPD) is expected to be correlated with kernel weight, flag leaf width (FLW) refers to spike weight, stem diameter (STD) or stem thickens refers to lodging tolerance provided that these characters are early predictors.

Master files for each visit are prepared using excel. These master files will be used to produce sub files to be analyzed using suitable statistical package. Excel files will be transferred to ASCII files before transforming to adopted statistical programs. Analysis will be made using multiple linear regression. Alternative characters expected to be multicolinear with each other are given later in addition to agricultural practices. Other data and in turn expected model are also given in an attempt to obtain accurately precise models. Earlier models with relatively few simple predictors are preferred.



Phenotypic Expression
Environmental Factors
E
Genetically Factors
G
Genotype x Environment
GxE
Yield Components
built in cultivator
Micro E
MIE
Agro-climatic Zone Location
ACZ
Year Y
Planting Dates PD
Harvest Dates HD
Growing Season Length GSL
Density D
Fertilization F
Irrigation I
Macro E
MAE
Soil Macro E:
Salinity S
Water Table WT
Texture T
Climatic CMAE:
Wind Speed WS
GDD
BSSHH
TPSSH
Rain

Figure (1)

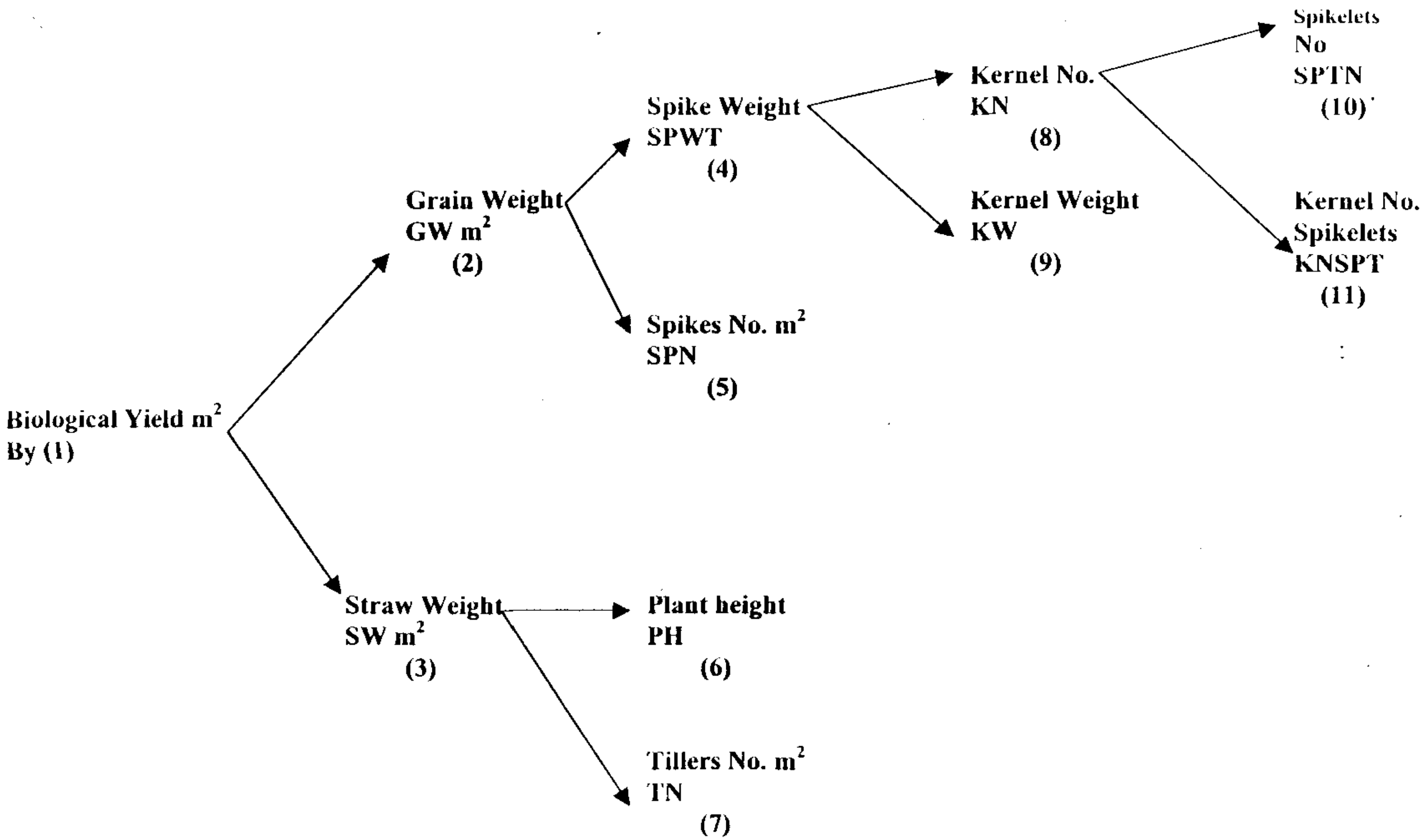

Biological Yield m2
By (1)
Grain Weight
GW m2
(2)
Straw Weight
SW m2
(3)
Spike Weight
SPWT
(4)
Spikes No. m2
SPN
(5)
Plant height
PH
(6)
Tillers No. m2
TN
(7)
Kernel No.
KN
(8)
Kernel Weight
KW
(9)
Spikelets
No
SPTN
(10)
Kernel No.
Spikelets
KNSPT
(11)

Figure (2)

Data Collected:

Code stage (2,3)
Seed Source
Planting date
Variety
Drainage
Planting method
Previous Crop
Stalk No.
Late boot
Emerged head
Plant height
Stem diameter
Flag leaf length
Flag leaf width
Herbs
Diseases
Insects
Fertilizer
Pesticides
No. of emerged head
Emerged head sample weight
Average weight / head
Average fertile spikelet / spike
Average rest of emerged head
Spike length
Spike diameter
Stem diameter
WT of late boot

B- Mathematical formula to execute model:

1. Simple linear regression and correlation according to the following equation:

   Y = a + bx

   Where: Y = dependent variable   X = Independent variable

   a = y intercept i.e. the value of y when X = $\varnothing$
   b = Simple linear regression $X \rightarrow y$
   i.e. the amount of change in Y when X increase by just one unit (Ignoring other factor)

Model evaluation:

Accuracy via r^2 and SE%
Where: r^2 = multiple coefficient of determination i.e. r^2% - percentage contributed of Y variability.

Precision: SE% measures the closeness of measurements.

r = correlation coefficient = cov. X y $\sqrt{var.X\ var.y}$

where var.X = $\sum(X - \bar{X})^2 / (n-1)$ var. y = $\sum(y - \bar{y})^2 / (n-1)$

$$SE = \sum (y - \hat{y}) / (n - 1)$$

$$SE\% = 100 * SE / \bar{y}$$

Where $\bar{y}$ = arithmetic mean of y

$\hat{y}$ is estimated using the following formula:

$\hat{y}$ = a + bx*

C. Data needed (included in table 1).

D. Plan to test the model:

1. Accuracy via r^2 = unity.
2. Precision via SE% = minimum.
3. Significant estimates:

t (b) = b/sb   t(r) = r/sr

$$Sb = \sqrt{\frac{1 - r^2}{n - 2}} x \frac{S_y}{Sx}$$

$$5r = \sqrt{\frac{1-r2}{n-2}}$$

Expectation is included in (table 1). Simple model also included in table 1 using just one independent variable, this is the minimum number of variables. However, when trying to evaluate the models including many characters or variables i.e. using independent variable X's over phonological or growth stage, stepwise multiple linear regression may be used. This point will be explained in detail later.

Standard errors (SE's):

$$SE^2a = \frac{var.y}{n} + \frac{\bar{X}^2 \, var.y/x}{(n-1)\,var.x}$$

$$= S^2 \bar{y} + \bar{x}^2 S^2_b$$

$$S^2b_{y/x} = \left(\frac{1-r^2}{n-2}\right)\frac{S^2_y}{S^2_x}$$

Where var. y = S^2y = independent variable var.

$\bar{x}$ = Arithmetic mean of independent variable.

Var. y/x = var. y x (n-1) $(1-r^2)$ / (n-2)
= About regression variance

(F) for both simple regression coefficient and regression coefficient.

$$= \frac{r^2(n-2)}{1-r^2}$$

ANOVA

V.S	DF	SS	MS	F
Regression	1	r^2ssy	r^2ssy	
About regression	n-2	$ssy-r^2ssy$	$\frac{ssy(1-r^2)}{n-2}$	$\frac{(n-2)r^2}{(1-r^2)}$
Total	n-1	ssy	Var.y	

Table (1): Field or Lab Variable to be used for Forecasting Final Yield Components in Sample Fields

Maturity Category	No. of Heads (Y_1)	Weight of Heads (Y_2)
	Independent Variable (X_1)	**Independent Variable (X_2)**
Pre-flag	No. of stalks	
Flag or early boot	**No. of stalks**	(FLW) Flag leaf width
Late boot or flower	Emerged heads + heads in late boot	Fertile spikelets Heads
Milk	Emerged heads + heads in late boot	Grains/heads Stem diameter Spike diameter
Soft dough	Emerged heads + heads in late boot	Grain/head
Hard dough	Emerged heads + detached heads and heads in late boot	Threshed weight per head adjusted to standard moisture

$Y_1 = a_1 + b_1 x_1$

$Y_2 = a_2 + b_2 x_2$

Table (1) Cont:

Maturity Category	Kernel (grain) No. (Y_3)	Kernel Weight (Y_4)
	Independent Variable	**Independent Variable**
1- Pre-flag		
2- Flag or early boot	**Spike length**	Spike diameter Stem diameter
3- Late boot or flower	Fertile spikelets/heads	

ANNEX B: WHEAT TIME SERIES DATA

Table B-1: Wheat total area, average yield and production in the old land
(1981-1999) .

Year	Total Area (1000 hectare)	Average Yield (t/ha)	Production (million tons)
1981	583	3.3	1.9
1982	572	3.5	2.0
1983	553	3.6	2.0
1984	491	3.7	1.8
1985	494	3.8	1.9
1986	305	3.8	1.9
1987	572	4.6	2.8
1988	592	4.8	2.8
1989	639	4.9	3.2
1990	745	5.5	4.0
1991	816	5.1	4.2
1992	745	5.7	4.3
1993	756	5.9	4.4
1994	723	5.8	4.2
1995	875	5.9	5.1
1996	828	6.1	5.1
1997	869	6.0	5.2
1998	849	6.4	5.4
1999	833	6.8	5.6

Source: Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, MOALR, Egypt.

Table B-2: Wheat total area, average yield and production in the New Land (1990-1999)

Year	Total Area (1000 Hectare)	Average Yield (t/ha)	Production (1000 tons)
1990	42	2.6	112
1991	63	3.8	219
1992	72	4.0	273
1993	73	4.3	302
1994	89	3.8	373
1995	100	4.5	441
1996	145	4.7	650
1997	147	4.1	608
1998	155	4.2	653
1999	131	5.3	694

Source: Agricultural Statistics, Economic Affairs Sector, Ministry of Agriculture and Land Reclamation, MOALR, Egypt.

Table B-3: Sample Size and Area Planted for the Sample Governorates, in Wheat Yield Forecasting Survey, Year 2000

Governorate	District	Variety	*Area Feddan	Number of Clusters (PSUs)**	Number of Fields	Number of Plots (60cm X 60cm)
Beheira	Delengat	S69,,61,,8	26,707	2	4	8
	Damanhour	S 69	26,210	2	4	8
	Gv. Total		235,697	4	8	16
Noubaria	Sugar Beet	S8	45,223	1	2	4
	Busttan	S69	22,185	1	2	4
	Total		67,408	2	4	8
Gharbia	Zefta	S69,,61	16,575	2	4	8
	Tanta	S69,,61	20,953	2	4	8
	Gv. Total		135,102	4	8	16
Kafr El-Sheikh	Sidi Salem	S61,,69,,8	23,158	2	4	8
	Kafr EL-Sheikh	S61,,69,,8	29,372	2	4	8
	Gv. Total		185,703	4	8	16
Sharkia	Dyarb Nigm	S69	16,887	2	4	8
	Zagazig	S69	29,801	2	4	8
	Gv. Total		307,000	4	8	16
Fayoum	Etssa	S69	43,187	2	4	8
	Fayoum	S69	27,753	2	4	8
	Gv. Total		148,899	4	8	16
Assuit	Assuit	S69,G164 ,Durum	18,145	3	6	12
	Dyrout	S69,G164	18,205	3	6	12
	Gv. Total		135,407	6	12	24
Total	Sample Districts Governorates			28	56	112

Source: Wheat yield forecasting study, MVE, year 2000 Egypt.
* Preliminary wheat crop area.
* Feddan = 4200 m^2
** Primary sampling unit (PSU) = cluster about 200 Feddan cultivated area.
S= Sakha G= Giza

Table B-4: Yield Estimation by Crop Cutting in Egypt, 2000
Area under Wheat Crop and Sample Distribution

Governorate	Selected Districts	Area	# Districts	# Strata	# Selected Clusters	# Plot
Beheira	Governorate	222,322	15	68	235	470
	Damanhour	26,210		8		
	Delengat	26,707		5		
	Sub Total 2 Dist.	52,917		13		
Gharbia	Governorate	135,102	8	27	180	360
	Tanta	20,953		3		
	Zefta	16,575		2		
	Sub Total 2 Dist.	37,528		5		
Kafr El Sheikh	Governorate	182,265	10	49	200	400
	Kafr El Sheikh	29,372		6		
	Sidi Salem	23,158		4		
	Sub Total 2 Dist.	52,530		10		
Sharkia	Governorate	236,203	15	49	210	420
	Zagazig	29,801		5		
	Diarb Negm	16,887		3		
	Sub Total 2 Dist.	46,688		8		
Fayoum	Governorate	148,899	5	17	151	302
	Fayoum	27,753		5		
	Etsa	43,187		5		
	Sub Total 2 Dist.	70,940		10		
Assuit	Governorate	133,665	11	34	175	350
	Assuit	18,145		2		
	Dayrout	18,205		9		
	Sub Total 2 Dist.	36,350		11		
New Lands & Nubaria	Governorate	157,488			15	30
	Al Bostan	22,185				
	Bangar El Sokar	45,223				
	Sub Total 2 Dist.	67,408				
Total Selected Governorate		1,283,352				
Total Egypt		2,500,604				5124

ANNEX C: WHEAT YIELD FORECASTING SURVEY 2000-DATA COLLECTION AND PROCESSING

Wheat Yield Forecasting Survey 2000
Data Collection and Processing

First Visit
(January 22-February 7)

About 50% of the samples were in maturity stage one (preflag) and 50% were in stage two (flag or early boot) at the time of the first field visit. Late boot heads appeared in 19 samples and emerged heads were found in 15 samples. Table 5-4 summarizes the important variables collected on the first field visit. A brief summary of table 5-4 data is shown below.

Average number of stalks per plot (60cm x 60 cm) 161
Standard error percentage 3.0%
Confidence limits ± 9.8 stalks
Minimum 66 stalks and maximum 319

The late boot heads appeared only in 19 plots

Average number of late boot heads per plot 26.3
Standard error percentage 15.6%
Confidence limits ± 8.6
Minimum 7 and maximum 71.

Emerged heads appeared only in 15 plots

Average number of emerged heads per plot was about 28.7
Standard error percentage 23.9%
Confidence limits ± 14.7
Minimum count 2 and maximum 76.

No lab measurements for the first visit were taken. Therefore we could say that, number of stalks counts per plot was the important factor collected in the first visit to forecast number of final heads, otherwise were minor factors.

Table C-1: Counts of Major Items as collected from Wheat Yield Forecasting First Visit

	Code Stage	**Stalks Number**	**Late Boot**	**Emerged Head**
Mean	1.51327	161.195	26.2632	28.7333
Standard Error	0.04723	4.91165	4.08953	6.8754
Median	2	152	24	22
Mode	2	126	19	2
Standard Deviation	0.50205	52.2116	17.8258	26.6283
Sample Variance	0.25205	2726.05	317.76	709.067
Kurtosis	-2.0334	0.34701	1.7543	-1.0209
Skewness	-0.0538	0.66787	1.48795	0.68784
Range	1	253	64	74
Minimum	1	66	7	2
Maximum	2	319	71	76
Sum	171	18215	499	431
Count	113	113	19	15
Confidence Level(95.0%)	0.09358	9.73181	8.59178	14.7463

Source: Calculated from the Wheat Yield Forecasting Data Survey

Second Visit (February 22- March 01). Table 5-5 summarizes the second visit counts and lab determinations. The main results are as follows:

I Field Observations

Maturity stage: 2 (flag or early boot) about 44%, and 3 (late boot or flower) about 56%.

Average number of stalks per plot 147.7 (from 113 plots)
Standard error 4.1 (2.78%)
Confidence limits ± 8.12 stalks
Minimum stalks number per plot 68
Maximum stalks number per plot 256

Average number of late boot heads per plot 40.75 (from 84 plots)
Standard error 4.53 (11.1%)
Confidence limits ± 9.01
Minimum number of late boot heads 1
Maximum number of late boot heads 149

Average number of emerged heads per plot 43.18 (from 60 plots)
Standard error 6.86 (15.89%)
Confidence limits ± 13.72
Minimum number 1
Maximum number 222

Average plant height 81.45 cm (from 108 plots)
Standard error 1.38 (1.69%)
Confidence limits ± 2.75 cm
Minimum height 30 cm
Maximum height 110 cm

Average length of flag leaf 26.88 cm
Standard error 0.46 (1.71%)
Confidence limits ± 0.92 cm
Minimum length 12 cm
Maximum length 38 cm

Flag leaf width 2.11 cm
Standard error 0.03 (1.42%)
Confidence limits ± 0.05 cm
Minimum width 1.5 cm
Maximum width 3.10 cm

II Lab Determinations

Average weight per green head 1.97gm.
Standard error 0.09 (4.57%)
Confidence limits ± 0.18 gm.
Minimum weight 0.82 gm.
Maximum weight 3.50 gm.

Average fertile spikelets per spike 18.11
Standard error 0.55 (3.04%)
Confidence limits ± 1.11
Minimum number 3
Maximum number 24.6

Average weight per late boot head 2.69 gm (enclosed head + flag leaf)
Standard error 0.14 (5.2%)
Confidence limits ± 0.28 gm.
Minimum weight 0.81 gm.
Maximum weight 4.90 gm.

Average of spike length 6.63 cm
Standard error 0.63 (9.5%)
Confidence limits ± 1.27 cm
Minimum number 1 cm
Maximum number 13.1 cm

Average of spike diameter 3.29 cm
Standard error 0.09 (2.74%)
Confidence limits ± .18 cm
Minimum number 2.60 cm
Maximum number 4.2 cm

Average of stem diameter 0.22 cm
Standard error 0.01 (4.55%)
Confidence limits ± 0.01 cm
Minimum number 0.15 cm
Maximum number 0.30 cm

From this visit the number of stalks per plot continued to be a very important variable to forecast number of final spikes. In addition, lab determinations could be used to forecast final weight per head. These variables such as average weight of green head, and number of fertile spikelets per spike may be used to forecast number of grains per head. Also we have to test other variables measured in this domain.

Table C-2: Summary of Data Collection Counts and Lab Measurements of Wheat Yield Forecasting As in the Second Visit

	Stalks Number	Late Boot	Emerged Head	Plant Height (cm)	Flag Leaf Length (cm)	Flag Leaf Width (cm)	Average green Weight/ Head (gm)	Average Fertile Spikelet Per Spike	Average Spike Length (cm)	Spike Diameter (cm)	Stem Diagonal (cm)	Average Weight of late Boot (gm)
Mean	147.72	40.75	43.18	81.45	26.88	2.11	1.97	18.11	6.63	3.29	0.22	2.69
Standard Error	4.10	4.53	6.86	1.38	0.46	0.03	0.09	0.55	0.63	0.09	0.01	0.14
Median	140.00	24.00	20.50	84.00	27.00	2.00	1.99	18.63	8.30	3.30	0.20	2.68
Mode	126.00	1.00	1.00	85.00	26.00	2.00	2.00	21.00	8.40	3.40	0.20	
Standard Deviation	43.58	41.51	53.11	14.39	4.77	0.26	0.58	3.67	4.12	0.42	0.04	0.97
Sample Variance	1899.29	1722.98	2820.39	207.13	22.76	0.07	0.34	13.44	17.00	0.17	0.00	0.94
Kurtosis	-0.35	0.10	2.82	1.32	1.08	1.78	0.21	6.19	-1.50	-0.45	0.02	-0.10
Skewness	0.48	1.03	1.72	-0.72	-0.32	1.11	0.38	-1.90	-0.27	0.31	0.88	0.33
Range	188.00	148.00	221.00	80.00	26.00	1.60	2.68	21.60	12.10	1.60	0.15	4.09
Minimum	68.00	1.00	1.00	30.00	12.00	1.50	0.82	3.00	1.00	2.60	0.15	0.81
Maximum	256.00	149.00	222.00	110.00	38.00	3.10	3.50	24.60	13.10	4.20	0.30	4.90
Sum	16692.00	3423.00	2591.00	8797.00	2848.90	224.00	86.47	796.78	284.98	72.35	8.51	128.96
Count	113.00	84.00	60.00	108.00	106.00	106.00	44.00	44.00	43.00	22.00	38.00	48.00
Confidence Level(95.0%)	8.12	9.01	13.72	2.75	0.92	0.05	0.18	1.11	1.27	0.18	0.01	0.28

Source: Calculated and compiled from the Wheat Yield Forecasting Survey and lab Measurements.

Third Visit. (March 23-April 02) Table 5-6 summarizes data collected during the third visit About one half of the plots were in mature stage 3 (late boot and flower and about one half in maturity stage 4 (milk). A few plots had reached maturity stage 5 (soft dough).

I Field Observation

Number of plots surveys is 113 plot.
Maturity stages: 3 (late boot and flowering) about 46%.
4 (milk stage) 49%
5 (soft dough) 5%

Average number of stalks per plot 132.78
Standard error 2.70%
Confidence limits ± 7.09
Minimum 59
Maximum 243

Average number of late boot heads per plot 10.78 (from 51 plot)
Standard error 2.52 (23.38%)
Confidence limits ± 5.05
Minimum number of late boot heads 1
Maximum number of late boot heads 86

Average number of emerged heads per plot 96.18
Standard error 5.60 (5.82%)
Confidence limits ± 11.09
Minimum number 1
Maximum number 239

Average plant height 107.84 cm
Standard error 1.14%
Confidence limits ± 2.44
Minimum height 57 cm
Maximum height 130 cm

Average length of flag leaf 26.40 cm
Standard error 1.70%
Confidence limits ± 0.9 cm
Minimum length 16 cm
Maximum length 41 cm

Table C-3: Summary of Data Collection Counts and lab Measurements of Wheat Yield Forecasting Third Visit

	Stalks Number	Late Boot	Emerged Head	Plant Height (cm)	Flag Leaf Length (cm)	Flag Leaf Width (cm)	Average Green Weight/ Head (gm)	Average Fertile Spikelet Per Spike	Average Number of Grains/ Head	Average Spike Length (cm)	Spike Diameter (cm)	Stem Diagonal (mm)	Average Weight of Late Boot
Mean	132.78	10.78	96.18	107.84	26.40	2.04	2.66	18.28	40.34	9.84	3.07	2.27	1.66
Standard Error	3.58	2.52	5.60	1.23	0.45	0.04	0.09	0.32	2.30	0.13	0.06	0.04	0.27
Median	131.00	4.00	112.00	110.00	26.00	2.00	2.52	18.73	37.10	9.95	3.10	2.20	1.39
Mode	105.00	3.00	12.00	110.00	23.00	2.00	1.86	18.80	36.80	10.50	2.50	2.50	
Standard Deviation	38.02	17.97	59.50	13.09	4.81	0.39	0.97	3.38	19.27	1.33	0.62	0.46	0.93
Sample Variance	1445.21	322.97	3540.13	171.35	23.17	0.15	0.93	11.44	371.46	1.76	0.38	0.21	0.86
Kurtosis	-0.10	8.90	-1.15	2.68	0.35	3.19	-0.30	9.05	-0.01	0.34	0.57	-0.34	-1.68
Skewness	0.37	3.00	-0.15	-1.13	0.66	-0.80	0.62	-2.02	0.20	-0.08	-0.05	0.43	0.29
Range	184.00	85.00	238.00	73.00	25.00	2.30	4.20	24.20	81.40	7.94	3.55	2.00	2.48
Minimum	59.00	1.00	1.00	57.00	16.00	0.70	1.08	0.30	2.40	5.56	1.25	1.50	0.55
Maximum	243.00	86.00	239.00	130.00	41.00	3.00	5.28	24.50	83.80	13.50	4.80	3.50	3.03
Sum	15004.00	550.00	10868.00	12186.00	2983.10	230.66	298.17	2046.87	2823.87	1102.40	343.80	254.66	19.87
Count	113.00	51.00	113.00	113.00	113.00	113.00	112.00	112	70.00	112.00	112.00	112.00	12.00
Confidence Level (95.0%)	7.09	5.05	11.09	2.44	0.90	0.07	0.18	0.63	4.60	0.25	0.12	0.09	0.59

Source: Calculated from the Wheat Yield Forecasting Data Survey and lab measurements.

Flag leaf width 2.04 cm
Standard error 0.04 (1.96%)
Confidence limits ± 0.07
Minimum width 0.7 cm
Maximum width 3.0 cm

II Lab Determinations

Average weight per green head 2.66 gm.
Standard error 3.38%
Confidence limits ± 0.18
Minimum number 1.08 gm
Maximum number 5.28 gm

Average fertile spikelets per spike 18.28
Standard error 1.75%
Confidence limits ± 0.63
Minimum number 0.3
Maximum number 24.5

Average number of grains per head 40.34
Standard error 2.30 (5.7%)
Confidence limits ± 4.60
Minimum number 2.40
Maximum number 83.8

Average spike length 9.84 cm
Standard error 0.13 (1.32%)
Confidence limits ± 0.25 cm
Minimum number 5.56 cm
Maximum number 13.5 cm

Average spike diameter 3.07 cm
Standard error 0.06 (1.95%)
Confidence limits ± 0.12 cm
Minimum number 1.25
Maximum number 4.8 cm

Average stem diameter 2.27 cm
Standard error 0.04 (1.76%)
Confidence limits ± 0.09 cm
Minimum number 1.5
Maximum number 3.5 cm

Fourth Visit (April 20-May 01). In the fourth visit about 60% of the samples had reached maturity stages 6 and 7 and about 65% of the samples were harvested by the end of April. This ratio increased to about 83% by May 02. A few fields were harvested at maturity stage five because the farmer was planning to harvest the field immediately.

All but 35 of the plots were harvested on the fourth visit. Data from the fourth visit is summarized in table 5-7 and critiqued below.

I Field Data

Average number of emerged heads 130.50
Standard error 2.69%
Confidence limits ± 6.96
Minimum number 54
Maximum number 239

Average plant height 108.58 cm
Standard error 1.09%
Confidence limits ± 2.33
Minimum height 70 cm
Maximum height 130 cm

II Lab Determinations

Average fertile spikelets per spike 17.86
Standard error 0.6 (3.36%)
Confidence limits ± 1.22
Minimum number 4.40
Maximum number 23.0

Average number of grains per head 40.21
Standard error 2.13 (5.3%)
Confidence limits ± 4.33
Minimum number 5.20
Maximum number 65.60

Average weight of grains per head 2.56 gm.
Standard error 0.17 (6.64%)
Confidence limits ± 0.35 gm
Minimum weight 0.32 gm
Maximum weight 4.56 gm

Average moisture content 16.71%
Standard error 5.14%
Confidence limits ± 1.70 %
Minimum moisture content 1.03%
Maximum moisture content 36.54%

Table C-4: Summary of Data Collection Counts and Lab Measurements of Wheat Yield Forecasting Fourth Visit

	Emerged Head #	Plant Height (cm)	Average Weight/ Green Head (gm)	Average Fertile Spikelet Per Spike	Average Number of Grains/ Head	Average Weight/Head (gm)	Average Weight/ Dried Head (gm)	Average Weight/ Dried Head 12.5% (gm)	Average Spike Length (cm)	Spike Diameter (cm)	Stem Diagonal (mm)
Mean	130.50	108.58	3.53	17.86	40.21	2.56	1.67	1.91	9.91	3.97	2.51
Standard Error	3.51	1.18	0.21	0.60	2.13	0.17	0.11	0.12	0.20	0.10	0.1
Median	130.00	110.00	3.54	18.40	39.60	2.52	1.62	1.85	9.80	4.10	2.5
Mode	116.00	110.00	3.16	18.00	38.60	3.40	1.34	1.53	9.80	4.40	2
Standard Deviation	37.36	12.49	1.25	3.55	12.60	1.01	0.64	0.73	1.20	0.62	0.60
Sample Variance	1395.95	156.03	1.57	12.62	158.87	1.02	0.41	0.54	1.44	0.38	0.36
Kurtosis	0.02	-0.27	0.75	6.02	1.25	0.21	0.23	0.23	0.90	0.37	2.91
Skewness	0.32	-0.65	-0.18	-2.08	-0.64	-0.09	-0.23	-0.23	0.75	-0.79	1.45
Range	185.00	60.00	5.60	18.60	60.40	4.24	2.74	3.13	5.50	2.75	3.00
Minimum	54.00	70.00	0.64	4.40	5.20	0.32	0.18	0.21	8.00	2.25	1.50
Maximum	239.00	130.00	6.24	23.00	65.60	4.56	2.92	3.34	13.50	5.00	4.50
Sum	14747.00	12270.00	123.70	625.00	1407.20	89.55	58.60	66.98	346.84	139.10	88.00
Count	113.00	113.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00	35.00
Confidence Level(95.0%)	6.96	2.33	0.43	1.22	4.33	0.35	0.22	0.25	0.41	0.21	0.21

Source: Calculated from the Wheat Yield Forecasting Data Survey and lab Measurements.

Harvest Visit (April 22– May 09)

Table 5-8 shows a descriptive analysis for varieties by governorates and variety in the harvest visit. The table includes the final count means, lab measurements and other descriptive statistics. A summary of the important results is given in the following paragraphs:

I Field Data

The average final emerged heads was 131.52 per plot as over all means. By varieties total head count/plot was: Durum 143.75, Sakha8 159, Sakha61 124.81, Sakha69 131.48, Giza164 135.6, and Gimmiza5 79.

The standard error of the total estimate was about 2.68%. By varieties the standard xxxxx was 3.35% for Sakha 69, 5.57 for Durum, 7.5% for Sakha 8, 7.29% for Giza 164, 8.19% for Sakha 61, and 22.78% for Gimmiza 5.

II Lab Determinations

The lab measurements from the harvest visit were very important for the final estimates of head weight, moisture, number of grains per head and other important variables. Table 5-8 summarizes and describes these variables for variety, governorate and total level.

The average number of emerged heads per plot counted in the laboratory was slightly higher than the field counts (131.87 compared with 131.39). The lab counts are probably more accurate because of the better working condition. The table shows all final lab measurements and determinations. The final average weight of grain per plot at 12.5% moisture was 245/17 gm with S.E 3.68%. Average of kernels per head was 1.89 grams with S.E. of 3.17%.

The five head sample selected outside the plot also showed a higher number of grains per head and weight per head than for the plants within the plot. This difference likely reflects a randomness in selecting the five head sample and the tendency to pick the larger heads.

Table 5-9 shows a comparison between wheat yield forecasting survey estimates results and estimates of both research stations and AERI estimates. The data demonstrate that the survey number of spikes per m^2 for all varieties except Gimmiza 5 were within range of research data. The average is $366/m^2$ for the survey, 350-450/m2 for research, and about $425/m^2$ for AERI data.

Number of grains per spike was different for most of varieties for survey data and research data except Giza 164. Varieties Sakha 69, Sakha 61, and Gimmiza 5 were less than research by 7-10gm/ spike, but for Durum, the survey data was greater than research data by 7 gm/spike.

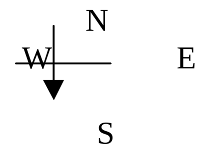
ANNEX D: WHEAT YIELD FORECASTING FORMS

Wheat Yield Forecasting Study - 2000

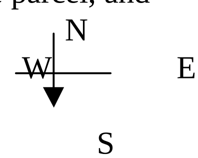
Form (A): Sketch of Selected Parcel

Governorate: ____________________ District: ________________________ Stratum: _________________
Village: ________________________ Hode: __________________________ Cluster: __________________
Parcel No. ______________________ Area: F __________ K ___________ Cultivator ________________
Number of Fields _______________ Selected Field: _________________ Length _____ Width ______
Visiting Date: ____

1) Sketch of parcel location among the hodes of the selected cluster, and location to the main road and to the village



2) Sketch of selected parcel showing measurements, natural separators inside and outside parcel, and measurements of the selected field.



3) General Data on Selected Parcel
   1) Soil
   2) Fertility degree
   3) Drainage
   4) Irrigation
   5) Irrigation Ratio
   6) Previous Crop
   7) Planting Date
   8) Other Observations
      a)
      b)
      c)

Wheat Yield Forecasting Study

Form (B): Wheat Plant Counts and Observations

Variety	Month	Year

1. General Data

Governorate: ______________ District: ________________ Stratum: _____________
Village: __________________ Code: _________________________ Cluster No.: ______________
Parcel No.: _____________________ Area: K F Farmer Name____________________ :
Number of Fields: _________ Selected Field __________ :Length:___________ Width: _____________
Planting Date:______ Planting Method: Broadcast___ Rows___ Ridges____ Drill____
Visiting Date:________________ Time: _______________ Visit Purpose: ___________________________

2. Plot Location

Plot 1 Plot 2
Random Length (m) ………………………………….
Random Width (m) ……………………………..…...……

3. Stage of Maturity (circle one code for each plot)

Blank	Maturity	Hard Dough	Soft Dough	Milk	Late Boot Emerged Head & Flowering	Flag or Early Boot	Pre-Flag	Maturity Stage
8	7	6	5	4	3	2	1	Count Area for Plot 1
8	7	6	5	4	3	2	1	Count Area for Plot 2
8, take plot 2 instead of 1. If both plots are 8, go to item 7	6 or 7, begin with item 5		4 or 5, begin with item 5		1, 2 or 3 begin with item 4			When maturity stage of plot 1 is:

Counts within Plots

Plot 2			Plot 1		
Total			Total		

To make counting easier, divide the counting area into four sections using metal stakes and cords. Record the counts for each quadrant in the appropriate box in items 4, 5 and 6.

4. Number of stalks (stems)………………….

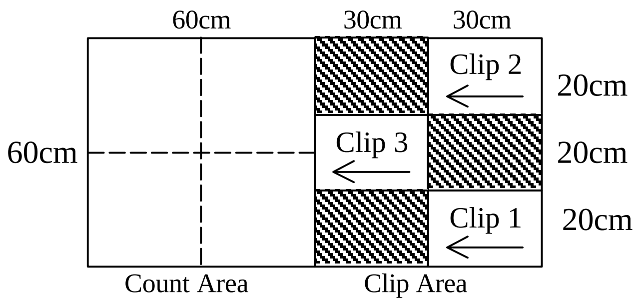
5. Number of heads in late boot stage in the counting area………

6. 6.a) Number of emerged heads…………

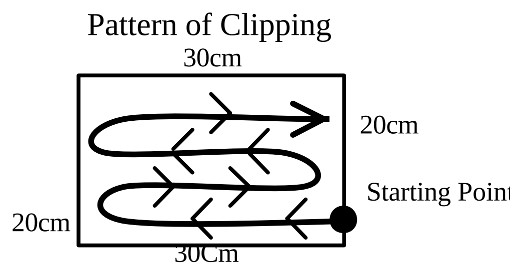
6.b) Number of detached heads on the general in the counting area (when the plot is harvested) …………………..

7. If the maturity stage code circled in item 3 for plot 1 (or plot 2 if plot 1 is blank) is:

1 or 2, go to item 10.
3, 4 or 5 go to item 8.
6 or 7, go to item 9.
8 for both plots, go to item 10. Write reason for plots being blank on Form (B), page 1.



Drawing 1



Drawing 2

8. Instructions for Clip Areas

Step (1): Divide the clip area into six 30 cm x 20 cm blocks as shown in the drawing 1 above. Clip only the designated block each month following the pattern shown in drawing 2 above.

Step (2): Clip all plants in the designated block 5 cm above the ground. Remove heads from plants by clipping 2 cm below the first spikelet. Place heads from the first 5 (or less if fewer than 5 emerged heads in the block) emerged heads in a small bag. Record the number of heads placed in the bag on the ID Tag.

Step (3): Remove emerged heads from the remaining plants from the designated block by clipping 2 cm below the first spikelet and place in large bag. Record number of heads placed in the bag on the ID Tag. Remove late boot heads from the plants by clipping below the flag leaf. Place late boot heads in a medium bag. Record the number of late boot heads placed in the bag on the ID Card. Attach all bags together with the ID Tags.
Repeat steps 1-3 for plot 2.

9. Instructions for Harvesting the Count Area

When maturity code is 6 or 7. Harvest plot 1 and plot 2 separately.
Step (1): Clip all late boot heads in the first quadrant by clipping below the flag leaf. Place late boot heads in a medium bag, and record number placed in the bag on the ID Tag.

Step (2): Clip all emerged heads in the first quadrant 2cm below the first spikelet. Place clipped heads in a large bag and record the number on the ID Tag.

Step (3): Repeat steps 1 and 2 for quadrants 2, 3 and 4.

Step (4): Collect all emerged heads on the ground in the clip area and place in a small bag.
Record the number of the heads clipped on the ID Tag. Attach all bags together with the ID Tags and send to the laboratory.
Repeat steps 1-4 for plot 2.

Engineer: ______________________________ Supervisor: ___________________________

10. Observations of Conditions in the Plots and in the Field

Plant Density	Lodging	Damage		Infestation			Humidity	Irrigation	Item
		Birds	Rats	Insects	Disease	Weeds			
									Plot 1
									Plot 2
									Field

Fertilizer (Qty, date, and method of application)

a) Manure ☐
b) Phosphorus ☐
c) Nitrate ☐
d) Potassium ☐

Pesticides Applied (Quantities and Dates)

a) ______________________________ ☐
b) ______________________________ ☐
c) ______________________________ ☐
d) ______________________________ ☐

Weather

a) Rains ☐
b) Winds ☐
c) Temperature ☐
d) Humidity ☐

Special Measurements

Observations	Plot 2	Plot 1	Item
From the base of the plant to the top of the head, excluding awns.			Average Plant Height (cm)
From the base of the flag leaf to leaf tip.			Average Flag Leave Length (cm)
Maximum width of flag leaf.			Average Flag Leaf Width (mm)
			Number of Sample Emerged Heads (5 or less)
			Number of Rest Emerged Heads in the Clip Area
			Number of Heads in Late Boot in the Clip Area

Other Information

a) General Crop Level: ______________________
b) Expected Date of Irrigation: ________________
c) Seed Source: ______________________________
d) Seed Rate: (kg./feddan) ____________________
e) Expected Harvesting Date: ____________________ ______________________________________

~~Time work ended:~~

Engineer:
Signature:

Supervisor:
Signature:

Evaluation Guide Lines

Irrigation	:	Excess	Sufficient	Insufficient	
Weed Infestation	:	Heavy	Moderate	Light	None
Disease Infestation	:	Heavy	Moderate	Light	None
Insect Infestation	:	Heavy	Moderate	Light	None
Rat Damage	:	Heavy	Moderate	Light	None
Lodging	:	Severe	Moderate	Light	None
Bird Damage	:	Severe	Moderate	Light	None
Plant Density	:	Heavy	Moderate	Light	Blank

Weather Last Month

Rains	:	Heavy	Moderate	Light	None
Winds	:	Stormy	Moderate	Calm	None
Temperature	:	Abnormal/Hot	Normal	Abnormal/Cool	
Air Humidity	:	High	Moderate	Low	
Crop Condition	:	Excellent	Good	Fair	Poor
Seed Source	:	Farmer	Coops	Other farmer	Trader
		1st Year			
		2nd Year			
		3rd Year			
		4th or More			

07 May, 2000

Wheat Yield Forecasting Study 2000

(Maturity Stages 3, 4, 5)

Form (C-1): Lab Data

Governorate ____________________ District _______________________ Stratum _________________
Village ________________________ Cultivator Name________________ Variety _________________

Date Lab Received Sample:

1) From Identification Tag

		Plot (1)	Plot (2)	
	…………...……… Total			a) Total heads (emerged and late boot)…... (number)
	Code of lower plot …….			b) Maturity stage ……………………………. (code)
	Average two plots... (cm)			c) Average plant height ………………………. (cm)
	Average two plots... (cm)			d) Average flag leave length ………………… (cm)
	Average two plots... (cm)			e) Average flag leave width ………………….. (cm)

2) Lab Data, Partial Sample of Emerged Heads (Small Bag). (use worksheet on back)

Plot (1)	Plot (2)	Total	
			a) Number of emerged heads in the sample (5 or less)……………..……….. number
			b) Total weight of emerged heads (clip stems 2cm below first spikelet) ……… gm

Complete (2C) and (2D) only for Maturity Stage 3

			c) Total Fertile Spikelets ………………………………………………… number
			d) Total Sterile Spikelets …………...……………………………………….. number

Complete (2E) only for Maturity Stages 4 and 5

			e) Total grains ………………………………………………………………… number
			f) Total weight of grains …………………………………………………… gm
			g) Total weight of grains after drying ………………………………………… gm

3) Lab Data on Remaining Heads

A) Emerged Heads (Large Bag)

			1) Total emerged heads, lab counting …………………………………...…number
			2) Total weight of emerged heads ………………………………………gm
			3) Average length of emerged head (take measurements of first partial sample if suitable number is not available) …...………………………cm
			4) Average diameter of emerged head (middle of head) ……………….cm
			5) Average stem diagonal (2 cm down the head base) …………………mm

B) Late Boot (Medium Bag)

			(1) Total Number, Lab Counting ………………………………………number
			(2) Total Weight of Late Boot ………………………………………….gm

Technician _________________________________ Date of Analysis ____________________________

Complete only for Maturity Stage (3)
(Counts)

Sterile Spikelets		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (2D)		

Fertile Spikelets		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (2C)		

Complete only for Maturity Stages (4,5)
(Counts)

Grains		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (E2)		

Wheat Yield Forecasting Study 2000

(Maturity Stages 6, 7)

Form (C-2): Lab Data

Governorate ___________________ District ______________________ Stratum ________________
Village _______________________ Cultivator Name________________ Variety _________________

Date Lab Received Sample:

1) From Identification Tag

		Plot (1)	Plot (2)	
	………..……… Total			a) Total heads (emerged, late boot, detached)….. (number)
	Code of Plot (1)			b) Maturity stage ……………………………. (code)

2) Lab Data, all heads clipped from plots (1) and (2)

A) Plot (1): a) Heads in the Sample 1/……………………………………………………… number
b) Total weight of heads ……………………………………………………….. gm
c) Average length of head ………………………………………………………. cm
d) Average diameter of head …………………………………………………… cm

B) Plot (2): a) Heads in the Sample 1/……………………………………………………… number
b) Total weight of heads ……………………………………………………….. gm
c) Average length of head ………………………………………………………. cm
d) Average diameter of head …………………………………………………… cm

C) Total weight of all heads ………… 2A (1)b + 2B (2)b ………………………………………….. gm

3) Threshed Grain, all heads of plots (1) and (2)

plot (1)	plot (2)	Total	
			e) Weight immediately after threshing grains If item (3a) is less than (2c)__ ( )Yes, go to (3b). If no, stop and advise supervisor.
			b) Weight immediately before drying ……………………………………gm
			c) Weight after drying …..…………………………………………………gm
			d) Moisture contents ……………………………………………..………%

Technician _________________________________ Date of Analysis ____________________________

1/ In case lab counting is different from field counting, follow the steps below:
a) Check the accuracy of counting of the specified plot.
b) Check the summation of the cards.
c) In case the difference is 2% or more, recount the heads and the plots.

08 May, 2000

Wheat Yield Forecasting Study 2000

(Maturity Stages 6,7)

Form (C-3): Lab Data

(A Special Study of a Sample of 5 Emerged Heads)

Governorate ___________________ District ______________________ Stratum _________________
Village ________________________ Cultivator Name________________ Variety _________________

Date Lab Received Sample:

1) From Identification Tag

		Plot (1)	Plot (2)	
	……………...……… Total			a) Sample (5 emerged heads) ………..…. (number)
	Code of lower plot …….			b) Maturity stage …………………………. (code)

2) Lab Data, Partial Sample of Emerged Heads (Small Bag). (use worksheet on back)

Plot (1)	**Plot (2)**	**Total**	
			a) Number of emerged heads in the sample (5 or less)……………..……….. number
			b) Total weight of emerged heads (2cm down the emerged head base) ………… gm

Complete (2C) and (2D) [Use table (1) and table (2)]

Plot (1)	**Plot (2)**	**Total**	
			c) Total Fertile Spikelets ……………………………………………………… number
			d) Total Sterile Spikelets …………...……………………………………….. number

Complete (2E) [Use table (3)]

Plot (1)	**Plot (2)**	**Total**	
			e) Total grains ………………………………………………………………… number
			f) Total weight of grains before drying ………………………………………… gm
			g) Total weight of grains after drying …………………………………………… gm
			h) Moisture content ………………………………………………………………. %

Technician _________________________________ Date of Analysis ____________________________

Table (1) (Counts)

Sterile Spikelets		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (2D)		

Table (2) (Counts)

Fertile Spikelets		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (2C)		

Table (3) (Counts)

Grains		
Plot (2)	Plot (1)	Head No.
		1
		2
		3
		4
		5
		Total
To be written in (2E)		

Wheat Yield Forecasting Study 2000

Form (E): Post-Harvest Gleanings

Governorate: ___________________ District: _______________________ Stratum: _________________
Village: _______________________ Cultivator: _____________________ Variety: _________________

Date:

Note: Post harvest gleaning should be finished immediately after harvest, but not more than three days after harvest. If the sample parcel has been plowed, select another parcel nearly to complete the post harvest gleanings.

Field Observation

To locate the post-harvest gleaning plot, add 3 meter to the measurements for locating the count plot. If the peat falls outside of the field, deduct 3 meters from measurements. Layout plot 60cm x 60cm using the frame.

	Plot (1)	Plot (2)
Random Length (mt)………………………………………………..		
Random Width (mt) ………………………………………………..		

Post harvest (put all gleanings of both plots in one bag)

1) Glean in both plots:
   - One) All complete heads.
   - Two) All parts of heads.
   - Three) All detached grains.

Did you select an alternate field for post-harvest gleaning? Yes ( ) No ( )

Send form (E) with the bag to the lab

Enumerator: ___________________________________ Supervisor: ____________________________
Date: ____

Lab Data for Post-Harvest

Date lab received sample:

2) Total weight of heads, kernels and hay in the bag ………………...……… (gm -,-)	
3) Weight of threshed grains ……………………………………………………. (gm -,-)	
4) Moisture contents ……………………………………………………………... (% -,-)	

Technician: ______________________________ Date of Analysis: _____________________________

Wheat Yield Forecasting Study 2000
ID Card for Harvesting

Governorate ______________________________ **District** __________________________
Cluster __________________________________ **Field** ____________________________
Cultivator Name __________________________ **Variety** __________________________
Plot: Random Length _____________________ **Random Width** ___________________

<u>Remarks</u>

	Plot No.
	Maturity Stage Code
	Date and Time of Harvest (count area)
	Total Complete Heads
	Total Late Boot Heads
	Total Detached Heads
	Grand Total of Heads

Enumerator __________________________ Signature ______________________________

Supervisor _ _________________________ Signature ______________________________

Wheat Yield Forecasting Study 2000
ID Card
Clip Area Sample

Governorate ________________________________ **District** ____________________________
Village ____________________________________ **Hode** ______________________________
Cultivator Name ____________________________ **Variety** ____________________________

Remarks

(2)	(1)	Plot No.
		Sample Date
		Maturity Stage Code
		Emerged Heads in Sample (5 or less)
		Late Boot Heads
		Rest Emerged Heads
		Total
		Average Plant Height (cm)
		Average Flag Leave Length (cm)
		Average Flag Leave Width (cm)

Enumerator ______________________________ Signature _________________________________
Date _ __________________________________ Time _____________________________________

ANNEX E: WHEAT YIELD FORECASTING-AERI EXPERIENCE 1993-1998

Wheat Yield Forecasting - AERI 1993-1998

The forecasting program was one of the planned studies of Agricultural Economic Research Institute, Sampling Research Section. It started with data collection activity with pilot surveys in the year 1984 with the help of USDA NASS for cotton and wheat, corn, cetrus forecasts.

Sample Design for Wheat Yield Forecasting

Wheat yield forecasting was conducted in five governorates as a research work during the period 1993-1998 (Gharbia, Kafr El Sheikh, Sharkia, Menofia, and Fayoum). The average yield of these five governorates represents the average of the country with slight modification.

Sample size was 60 plots for each governorate allocated among the largest three cultivated wheat area district, 20 plots for each district distributed between two selected villages per district, selecting 10 cultivators growing wheat crop within each of the selected villages which randomly locate the plots at the last 10 days of February with the help of steel frame. The plot consists of 3 small plots 60 cm x 60 cm. The data were collected during 3 visits of the last 10 days of February, of March, and of April, in addition to the harvest visit in May. Table (1) shows the sample design and table (2) shows the comparison between forecasts estimates for the period 1993-1998, crop cutting estimates, and the final estimates of the Ministry.

Table E-1: Wheat Yield Forecasting, Sample Design 1998

Governorate	District	# Villages	# Fields Selected
Gharbia	Tanta	2	20
	Senta	2	20
	Zifta	2	20
Total		**6**	**60**
Kafr El Sheikh	Kellin	2	20
	Kafr El Sheikh	2	20
	Dessouk	2	20
Total		**6**	**60**
Sharkia	Abu Kebir	2	20
	Zagazig	2	20
	Menya El Kamh	2	20
Total		**6**	**60**
Menofia	Quesna	2	20
	Tala	2	20
	Menouf	2	20
Total		**6**	**60**
Fayoum	Senouris	2	20
	Tamia	2	20
	Fayoum	2	20
Total		**6**	**60**
Grand Total		**30**	**300**

Source : ARC, AERI, Sampling Research Section Survey

Table E-2: Wheat Yield Forecasting*, Crop Cutting Comparing with Final Estimates** in Egypt, 1993-1998**

Ardab/Feddan

Year	End Feb. (1)	End Mar. (2)	End Apr. (3)	May (Harvest)	Crop Cutting	Final
1993	16.74	16.53	-	-	15.01	14.99
1994	16.11	16.29	15.79	-	14.01	14.01
1995	16.94	15.56	15.44	15.42	15.11	15.19
1996	15.73	15.62	15.54	-	15.67	15.71
1997	16.66	16.19	16.09	15.81	15.60	
1998	16.51	16.58	16.60	16.31		16.78

* AERI forecasts.

** CAAE estimates.

Note: Ardab = 150 kg. Feddan = 4200 m^2

Forecast Modelling

Survival Models

Wheat yield forecasting in Egypt based on the survival ratios of heads, for months of February, March, April, and May, and the average of grain per head from the previous years. Table (3) shows some of these measurements.

Table E-3: Survival Ratios of Wheat Yield Forecasting and Average Weight of Grain Per Head, Period 1993 - 1998

Year	End Feb. (1)	End Mar. (2)	End Apr. (3)	May (Harvest)	Average Weight of Grains/Head (gm)
1993	0.75	0.90	-	1.00	1.550
1994	0.87	0.90	-	1.00	1.524
1995	0.89	0.91	0.94	1.00	1.499
1996	0.91	0.96	0.97	1.00	1.512
1997	0.92	0.95	0.97	1.00	1.559
1998	0.81	0.85	0.92	1.00	1.590

Survival Ratio of: February: Stalks number/final heads number per plot.

March: (Emerged heads+heads in late boo)t/final heads number.

April: Emerged heads/final heads number

Statistical Models (1995, AERI)

February: $\hat{y} = 11.1 + 0.90X_1$ R^2 0.89
$\quad\quad(4.08)$

March: $\hat{y} = 4.48 + 0.95X_4$ R^2 0.95
$\quad\quad(76.56)$

April: $\hat{y} = 22.94 + 0.85X_4$ R^2 0.78
$\quad\quad(32.83)$

$\hat{y} = 2.47 + 0.74X_1 + 0.24X_3$ R^2 0.49
$\quad\quad(28.38) \quad (9.53)$

Where:

$\hat{y}$ Final head numbers per plot
X_1 Number of stalks per plot
X_2 Heads in late boot per plot
X_3 Emerged heads per plot
X_4 Emerged heads + heads in late boot

Wheat Growing Stages in Egypt

Cultivators usually grow wheat in first half of November in Upper Egypt and in second half of November in Lower Egypt. The harvest mostly in May. Now there are some early varieties ripe in March and April. There are many varieties in Egypt. The important stages of growing are:

Pre flag stage
Early boot or flag stage
Late boot or flower stage
Milk stage
Soft dough stage
Hard dough stage
Ripe stage

Table E-4: Wheat Yield Forecasting in Egypt, 1996 (February Data)
Survival Ratio Model

Item	Unit	Period	Average	Upper Limit	Lower Limit
Number of stalks/plot	No.	1996	171,008	175,999	166,017
Survival ratio (1st of March)	Coef.	*95/92	0.91	0.91	0.91
Expected number of heads at harvest/plot	No.	1996	155,617	160,159	151,075
Average weight of grains/head	Gm.	*95/92	1,512	1,512	1,512
Average weight of grains/plot	Gm.	1996	235,293	242,160	228,425
Yield/feddan from sample	Ard./fed	1996	18,301	18,835	17,767
Harvest loss	Ard./fed	*95/92	249	249	249
Net yield	Ard./fed	1996	18,052	18,586	17,518
Coef. Transformation (sample to N.L)	Coef.	*95/92	0.96	0.96	0.96
Net yield of valley land	Ard./fed	1996	17,330	17,822	16,817
Total valley area of wheat	Mil.Fed	1996	2,099	2,099	2,099
Yield o new lands for wheat	Ard./fed	1995	8.92	8.92	8.92
Area of new lands for wheat	Mil.Fed	1996	489	489	489
Yield of new lands	Ard./fed	1996	15,730	16,132	15,934
Total production of valley	Mil. ton	1996	5,456	5,611	5,295
Total production of new lands	Mil. ton	1996	654	654	654
Expected total production of Egypt	Mil. ton	1996	6,110	6,265	5,949

* Average period (1992-1995)

Source: Agricultural Research Center (ARC), Agricultural Economic Research Institute (AERI), Sampling Research Section, Wheat Yield Forecasting, February Visit, 1996.

Notes: Plot = 60 cm x 60 cm
Feddan = 4200 m^2
Ardab = 150 kg.

Table E-5: Wheat Yield Forecasting in Egypt, 1996 (March Data)
Survival Ratio Model

Item	Unit	Period	Average	Upper Limit	Lower Limit
Emerged heads + heads in late boot	No.	1996	160,733	162,967	158,499
Survival ratio (late March)	Coef.	*95/92	0.96	0.96	0.96
Expected number of heads/plot	No.	1996	154,304	156,448	152,159
Average weight of grains/head	Gm.	*95/92	1,512	1,512	1,512
Average weight of grains/plot	Gm.	1996	233,308	236,549	230,064
Yield/feddan from sample	Ard./fed	1996	18,147	18,399	17,894
Harvest loss	Ard./fed	*95/92	249	249	249
Net yield	Ard./fed	1996	17,898	18,150	17,645
Coef. transformation (sample to N.L)	Coef.	*95/92	0.96	0.96	0.96
Net yield of valley land	Ard./fed	1996	17,182	17,424	16,939
Total valley area of wheat	Mil.Fed	1996	2,099	2,099	2,099
Yield o new lands for wheat	Ard./fed	1995	8.92	8.92	8.92
Area of new lands for wheat	Mil.Fed	1996	489	489	489
Yield of new lands	Ard./fed	1996	15,621	15,817	15,424
Total production of valley	Mil. ton	1996	5,410	5,486	5,333
Total production of new lands	Mil. ton	1996	654	654	654
Expected total production of Egypt	Mil. ton	1996	6,064	6,142	5,987

* Average period (1992-1995)

Source: Agricultural Research Center (ARC), Agricultural Economic Research Institute (AERI), Sampling Research Section, Wheat Yield Forecasting, February Visit, 1996.

Notes: Plot = 60 cm x 60 cm
Feddan = 4200 m^2
Ardab = 150 kg.

Table E-6: Wheat Yield Forecasting in Egypt, 1996 (April Data)
Survival Ratio Model

Item	Unit	Period	Average	Upper Limit	Lower Limit
Emerged heads	No.	1996	158,213	162,560	153,866
Survival ratio (end March)	Coef.	*95/92	0.97	0.97	0.97
Expected number of heads/plot	No.	1996	153,467	157,663	149,250
Average weight of grains/head	Gm.	*95/92	1,512	1,512	1,512
Average weight of grains/plot	Gm.	1996	232,042	236,417	225,666
Yield/feddan from sample	Ard./fed	1996	18,048	18,544	17,552
Harvest loss	Ard./fed	*95/92	249	249	249
Net yield	Ard./fed	1996	17,799	18,206	17,303
Coef. transformation (sample to N.L)	Coef.	*95/92	0.96	0.96	0.96
Net yield of valley land	Ard./fed	1996	17,087	17,478	16,611
Total valley area of wheat	Mil.Fed	1996	2,099	2,099	2,099
Yield o new lands for wheat	Ard./fed	1995	8.92	8.92	8.92
Area of new lands for wheat	Mil.Fed	1996	489	489	489
Yield of new lands	Ard./fed	1996	15,544	15,861	15,158
Total production of valley	Mil. ton	1996	5,380	5,503	5,230
Total production of new lands	Mil. ton	1996	654	654	654
Expected total production of Egypt	Mil. ton	1996	6,064	6,157	5,884

* Average period (1992-1995)

Source: Agricultural Research Center (ARC), Agricultural Economic Research Institute (AERI), Sampling Research Section, Wheat Yield Forecasting, February Visit, 1996.

Notes: Plot = 60 cm x 60 cm
Feddan = 4200 m^2
Ardab = 150 kg.

Table E-7: Wheat Yield Forecasting in Egypt, 1996 (May Data)
Survival Ratio Model

Item	Unit	Period	Average	Upper Limit	Lower Limit
Emerged heads/plot	No.	1996	158,027	162,530	153,524
Average weight of grains/head	Gm.	*95/92	1,512	1,512	1,512
Average weight of grains/plot	Gm.	1996	238,937	245,745	232,128
Average yield/feddan	Ard./fed	1996	18,937	19,114	18,050
Harvest loss	Ard./fed	*95/92	0.249	0.249	0.249
Net yield	Ard./fed	1996	18,336	18,865	17,801
Coefficient benefits	Ard./fed	*95/92	0.97	0.97	0.97
Net yield (without benefits)	Ard./fed	1996	17,786	18,299	17,267
Coef. transformation (sample to N.L)	Coef.	*95/92	0.96	0.96	0.96
Net yield of valley land	Ard./fed	1996	17,075	17,567	16,576
Total valley area of wheat	Mil.Fed	1996	2,099	2,099	2,099
Yield o new lands for wheat	Ard./fed	1995	8.92	8.92	8.92
Area of new lands for wheat	Mil.Fed	1996	0.489	0.489	0.489
Yield of new lands	Ard./fed	1996	15,534	15,933	15,129
Total production of valley	Mil. ton	1996	5,376	5,531	5,219
Total production of new lands	Mil. ton	1996	0.654	0.654	0.654
Expected total production of Egypt	Mil. ton	1996	6,030	6,185	5,873

* Average period (1992-1995)

Source: Agricultural Research Center (ARC), Agricultural Economic Research Institute (AERI), Sampling Research Section, Wheat Yield Forecasting, February Visit, 1996.

Notes: Plot = 60 cm x 60 cm
Feddan = 4200 m^2
Ardab = 150 kg.

ANNEX F: AGRONOMIC PROSPECTIVE OF WHEAT PRODUCTION AND YIELD IN EGYPT

Agronomic Prospective of Wheat Production and Yield in Egypt

Importance of Wheat to Egypt.

Wheat has been considered the first strategic food crop for more than 7000 years in Egypt . It has maintained its position during that time as the basic staple food in urban areas and mixed with maize in rural areas for bread making.

In general, over 30 percent of the caloric intake is from wheat flour products, primarily bread. The government of Egypt has subsidized bread consumption for decades as a way to raize nutritional levels and to benefit low-income families.In addition, wheat straw is an important fodder.

Historically, wheat yields have tended to increase gradually over the past five decades. Wheat production increased from 1.3 million tons in 1950 to 1.9 million tons in 1980. However, the production was far below to meet the growing population of the country. In Egypt the annual per capita consumption of wheat has been estimated by about 200 kilograms. The population growth rate of 2.9 % annually between 1965 and 1980 and of 2.6% in the decade of the 1980 ,s was not matched by similar increase in wheat production . This resulted in increasing wheat imports to three folds from the mid 1970,s. Therefore, increasing wheat production becomes an important national goal to reduce the amount of wheat imports , save foreign currency , and provide enough food to meet increasing domestic demand . To face the above challenges, a vigorous research program started to improve genetic potential, develop new production systems, and introduce wheat to new areas.
It was anticipated that high and stable wheat yield could be achieved, if wheat improvement emphasis is directed to solving the problems of non availability of appropriate varieties, poor agricultural practices , poor water management, shortage of nitrogen fertilizer as well as other major and minor elements, late planting , and aphid and diseases infestations .

Moreover, increasing food demands have led to cultivate wheat under marginal conditions. Drought and/or water stress resistance and heat tolerance are major breeding constraints. Environments with drought, water, and heat stress encompass about 80,000 hectares at Northwest Coast. About 6000 hectares at the New Valley, and about 220,000 hectares at Upper Egypt governorates. Salinity is also a problem on about 30 % of the cultivated areas in Egypt.

However, during the past 20 years, wheat cultivation in Egypt has changed out of recognition. Wheat grain yield per unit area and total wheat production has been triggered since 1987. Area under wheat increased from 600,000 hectares in 1987 to 1.0 million hectares in 1999.In the old land, the average grain yield increased from 4.6 t/ha in 1987 to 6.8 t/ha in 1999. Consequently, total wheat production in the old land reached 5.6 million tons in 1999 as compared with 2.8 million tons in 1987.

Since 1990, wheat cultivation was introduced to the newly reclaimed desert areas .Its area reached over 150000 ha during 1998 producing 653000 tons with yield average of 4.2 t/h . In 1999, the average grain yield reached 5.3 t/h . Table.

The national breeding program is concentrating its activities in Nubaria Research Station to select better adapted and higher yielding varieties. Our expectation that area under wheat will be increased dramatically in the newly reclaimed sandy soil.

Moreover, since 1990, wheat cultivation was also introduced to about 0.27 million hectares of marginal rainfed area (150-250 mm annual rainfall).
These efforts resulted in increasing area under wheat to about one million hectares.

The national average of wheat yield has reached 6.3 t/ha in 1999. Consequently, the country production of wheat in 1999 have reached 6.3 million tons.

These tremendous efforts cut wheat imports from 7.2 million tons in 1987 to 6.6 million tons in 1990 and to 6.0 million tons in 1999, despite the growing population that increased by about 18 millions from 1980 to 1999.

Genotypes and Varieties :
Development of high –yielding and adapted varieties is a key to the future improvement of wheat production .The strategy of the National wheat Research Program (NWRP) is to select from among introductions and regionally collected germplasm that show good adaptation to the variable conditions and good tolerance to the major pests. Mass selection was used as early as 1920 to improve some Indian bread wheat introductions as well as local materials of bread and durum wheats.

Hybridization has been used to develop new improved wheat genotypes as early as 1940. Since 1960,s the new technology linked with the green revolution stimulated the Egyptian breeders to make marked efforts to attain the high wheat productivity. The new methodologies developed for wheat improvement are based on a multidisciplinary team strategy. Thousands of varieties and /or accessions have been introduced from several International

Centers and Organizations as CIMMYT, ICARDA, FAO and USDA. Those exotic genetic material have been actively screened for adaptation to the Egyptian environments as well as identifying types with desirable characteristics and high yield potential to be selected or to be used in breeding. This approach has assisted the Egyptian wheat breeders to define and select some cultivars of bread and durum wheat which are favored by the growers in addition to providing source of well –adapted gremplasm for current and future breeding work.

Table 3 indicates the released cultivars of bread and durum wheat, their pedigree, year of release and their actual yield averages since 1921 till present.

In spite of the limited area under wheat which is estimated by about one million hectare, the number of grown varieties are relatively high, as the policy is to raise more than one variety per given location , on condition that those cultivars should carry various genes for resistance against the three rusts as the main diseases confronting wheat production in Egypt. This policy helped to save-guard the crop and to buffer against sudden break of rust attach.

<u>Bread Wheat Varieties</u>:

The current grown bread wheat cultivars are about 13 varieties namely Sakha 61, 69,8,93; Giza 164, 165, 168; Gemmeiza 5,7,9; and Sids 1,4,6 and 7. According to the varietal policy the varieties Sakha 61 , Sakha 93 , Giza 168 and Gemmeiza 9 are recommended to be grown in Northern Delta Region due to their highly resistance to rusts specially stripe rust. For Middle and Southern Delta Region the varieties Sids 1; Gemmeiza 5, 7, 9; Sakha 69 are recommended. As for Middle Egypt the varieties Sids 1,4 Giza 164; Giza 165 and Sakha 69. The bread wheat varieties Giza 164 ,165, Sids 4,6 and 7 are recommended to be grown in Upper Egypt Region. As for the newly reclaimed desert areas in Nubaria, Gemmeiza 5 , Gemmeiza 7 ,9 and Sakha 61 are recommended . The variety Sakha 8 is recommended to be grown in Salt-affected soils in the Delta and Middle Egypt regions.

It is of interest to mention that the variety Sakha 69 occupies approximately 50% of the total area under wheat as it is favored by most of the wheat growers due to its wide adaptability. Unfortunately, this represent a very risky situation and put the crop under threat by stripe rust attack as its resistance was broken by new aggressive stripe rust races. It is planned to eliminate its cultivation in the coming two seasons and replace it by the newly released resistant cultivars as G.168 , Gemmeiza 9 , Sakha 93 and Sakha 61 .

Table 4 indicates the main characteristics of the commercially grown bread wheat cultivars.

Durum Varieties :
So far five durum wheat varieties namely Beni-suef 1,3,4 and Sohag 2 and 3 are grown in Middle and Upper Egypt Regions . The varieties; Beni-suef 1, 3, 4 are recommended to be grown in Middle Egypt mainly in El-Minia, Beni-Suef and El-Fayoum . As for Upper Egypt, it is recommended to grow Sohag 2 and 3, Beni-Suef 1,3 and 4 in Assuit, Sohag, Quena and Aswan Governorates.

Table 5 indicates the main characteristics of the commercially grown durum wheat cultivars.

Long Spike Varieties :

Long spike wheat varieties are characterized by increased number of kernels per spike, number of kernels per spikelet and kernel weight.

The first released cultivars; Sids 4,5,6,7,8,9 and 10, were of mono-tillage nature and faced with improper management from growers in addition to their susceptibility to stripe rusts . A vigorous program is concentrating to incorporate high tiller number and resistance to rusts in addition to other desirable agronomic traits to those long spike cultivars through utilization of the traditional breeding methodologies in addition to biotechnological activities as molecular markers. The new two long spike cultivars Gemmeiza 7 and Gemmeiza 9 showed higher yield and wider adaptability to the Delta Region. They possess resistance to salinity and rusts. Their actual yield ranged between 7-8 t/ha.

Table F-1:Cultivars released by Wheat Research Section, and NWRP, ARC pedigree, year of release and actual grain yield.

Actual yield t/ha	year	Pedigree,	Cultivar
		Bread Wheat	
2.5	1921	Selected Local Variety	Hindi D
2.6	1921	Selected Local Variety	Hindi 62
2.7	1921	Selected Local Variety	Mabrouk
2.5	1921	Selected Local Variety	Mokhtar
2.6	1921	Selected Local Variety	Giza135
2.7	1921	Selected Local Variety	Tosson
2.6	1947	Hindi90/ Keya B256	Giza 139
2.6	1958	Rgent /2* Giza 139	Giza 144
2.4	1958	Hindi 62/ Mokhtar	Giza 145
2.4	1958	Hindi 62/ Mokhtar	Giza 146
3.0	1958	Hindi D/New Thatcher	Giza 147
3.2	1959	Rgent /2*Mabrouk	Giza 148
3.3	1960	Mida- Cadet /2*Giza 139	Giza 150
4.5	1968	Regent /2*Giza139//Mida Cadet/2*HindiI62	Giza 155
4.2	1972	Rio-Negro /2*Mentana //Kenya /3/*2 Giza 135/Line 950	Giza 156
5.8	1972	Penjamo /GB55/118156	Mexipak 65
6.0	1972	Penjamo /GB 55	Super X
5.0	1973	C271/W1(E)//Son 64	Chenab 70
5.0	1976	Cno 67//SN64/KLRE/3/8156 PK 3418-6S-0S-0S.	Sakha 8
5.6	1977	Giza 155//Pit62/LR64/3/Tzpp/Knott	Giza 157
5.0	1977	Giza 156/7C	Giza 158
6.0	1980	Inia/RL 4220//7C/Yr “S” CM 15430-25-55-0S-0S	Sakha 61
6.3	1980	Inia/RL 4220//7C/Yr “S” CM 15430-25-65-0S-0S	Sakha 69
5.5	1982	Chenab 70/Giza 155	Giza 160
5.7	1987	Napo 63/Inia 66//Wern “S” S.1551-1S-1S-1S-0S	Sakha 92
6.0	1987	Vcm//Cno 67/7C/3/Kal/Bb CM8399-D-4M-3Y-1M-1Y-1M-0Y	Giza 162
6.3	1987	T. aestivum /Bon //Cno /7C CM33009-F-15M-4Y-2M-1M-1M-1Y-0M	Giza 163
6.0	1987	KVZ/Buha “s”//Kal /Bb CM33027-F-15M-500y-	Giza 164
6.3	1991	0MCno/Mfd//Mon “S” CM43339-C-1Y-1M-2Y-1M-2Y-0B	Giza 165
6.3	1991	Maya74/On//1160.147/3/Bb/1991Gall/4/Chat “S” CM58924-1GM-OGM	Gemmieza 1
1.4 (rainfed)	1994	N.S.732/Pim/ Vee “S” Sd 735-4sd-1sd-1sd-0sd .	Sahel 1
7-8	1994	Maya”S”/Mon”S”/CMH74.A592/3/Giza 157*	Sids 4
7-8	1994	Maya”S”/Mon”S”/CMH74.A592/3/Giza 157SD10001-7sd-4sd-2sd-0sd	Sids 5
7-8	1994	Maya”S”/Mon”S”/CMH74.A592/3/Sakha 8*2 SD10002-4sd-3sd-1sd-0sd	Sids 6
7-8	1994	Maya”S”/Mon”S”/CMH74.A592/3/Sakha 8*2 SD10002-8sd-1sd-1sd-0sd	Sids 7
		Maya”S”/Mon”S”/CMH74.A592/3/Sakha 8*2 SD10002-	Sids 8

7-8	1994	14sd-3sd-1sd-0sd	
6.6	1995	Au/UP301//Gll/SX/Pew“S”/4/ Mai“S”/ May“S”//Pew“S”CM67245-C-1M-2Y-1M-7Y-1M-0Y	Giza 167
6.7	1996	HD2172/Pavon “S”//1158.57/Maya74 “S” Sd46-4Sd-2Sd –1Sd-0sd	Sids 1
6.3	1997	Bb/7C*2//Y50/Kal*3//Skha8/4/Prv/WW/5/3/Bg “S”//On CGM. 4024-1GM-13 GM-2GM-0GM	Gemmieza 3
6.7	1998	Vee “S”/SWM 6525 CGM 4017-1GM-6GM-3GM-0GM	Gemmieza 5
7-8	1999	CMH74 A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM.	Gemmieza 7
7-8	1999	Ald “S”/Huac“S”//CMH74A.630/5x CGM4583-5GM-1GM-0GM.	Gemmieza 9
6.5	1999	MIL/BUC//Seri CM93046 – 8M-0Y-0M-2Y-0B	Giza 168
6.5	1999	Sakha 92/TR 810328 S 8871-1S-2S-1S-0S	Sakha 93
		Durum Wheat	
2.3	1921	Selected Local Variety	Baladi 116
2.4	1921	Selected Local Variety	Dakar49
2.5	1921	Selected Local Variety	Dakar 52
6.3	1977	Gdo vz 469/Jo”S”//61.130/Lds	Sohag 1
6.3	1987	Cr”S” /Pelicano//Cr”S”/G”S”	Sohag 2
6.3	1987	Jo”S”/AA//g”S”	Beni Suef 1
6.0	1991	Mexi “S” /Mgh/51792/Durum 6	Sohag 3
6.3	1995	Corm”S”/Rufo”S”CD4893-10Y-1M-1Y-0M	Beni Suef 3
6.5	1999	Rok”S”/Mexi 75/4/ “S”//Ruff’s”/FG”S”/3/ Mexi 75 SDD1462-2sd-1sd-0sd	Beni Suef 4

Source: Wheat Research Section, Field Crops Research Institute, ARC, MOALR, Egypt..

The Yield Triangle :

Total yield of wheat per feddan (4200m2) = .42 ha) is the combined effect of (1) number of fertile spikes per feddan (2) number of kernels per spike and (3) kernels weight.

Number of spikes per feddan is considered the main contributer to the obtained grain yield and is affected heavily by cultural practices and how the crop is managed . This production factor is not even compensated by the other two production factors combined i.e. number of kernels per spike and spike weight . Under Egypt,s condition this number ranges between 300 – 700 spikes /m2 with a national average of 400 spikes /m2 resulting in a country yield average of 17.8 ardab/fedan (6.3 t/ha) in the old land , ranging from 12-28 ardabs/feddan (4.5 – 10.5 t/ha) .

Number of kernels per spike of the currently grown cultivars is averaged 55 kernels/spikes in the normal spikes cultivars and 75 kernels per spike in the long spike cultivars.

However ,1000 kernels weight ranges between 38 grs upto 72 grs.

Each cultivar of wheat has a genetically determined yield potential , environment determines how closely actual yield approaches genetic potential. It is fairly certain that the full yield potential is never achieved , because at some time during the growing season one or more of the environmental factors are limiting . Moreover , any production factors which limits the maximum contribution of any one or more of the yield triangle sides results in decreased yields.

The national wheat yield average inspite is relatively high (6.3 t/ha) there is 20% gap between actual yield as compared to potential yield due to poor management, lack of extension, small farm size,and poor cultural practices.

The modern high yielding varieties have been widely adopted in about 80% of wheat area. Farmers also take advantage of more efficient fertilizer use, better tillage techniques, more appropriate crop rotation, adequate stand establishment, and weed and aphids control. Land preparation with tractors, using drills, and mechanical threshing have also been widely adopted.

Sowing date is one of the most important factors influencing maximum grain yield. Planting through November does not affect the yield negatively in most Egyptian regions. However, the results indicated that early November planting is optimum for Upper Egypt, while planting around mid November is optimum for the Delta and Middle Egypt.

The results reported that there was slight increase in grain yield by increasing seeding rates. The optimum seeding rates for both dry and wet planting were 150 and 180 kg / ha, respectively. However, drilling grain into well - prepared soil decreased the optimum seeding rate to 110 kg / ha. Chisel plowing, disc harrowing, and dry - leveling produced maximum grain yields. Laser-leveling increased yield with all planting methods.

Increasing nitrogen (N) level up to 250 kg / ha produced the highest grain yield under heat stress conditions in the new land throuhg Nubaria and Upper Egypt. In the old land, the highest economic grain yield was obtained by 180 kg N / ha and 35 P2 O5 / ha.

Nitrogen application should be splitted between the first irrigation (tillering stage) and the second irrigation (starting of stem elongation stage) but early application during the planting time is not necessary. However, the activating early dosage could be important for low fertilitys soil. Phosphorus should be incroporated to the soil before planting.
Using five and six irrigations for wheat fields boosted grain yields substantially by about 21 - 35 %.

Results indicated that plots receiving two irrigations before stem elongation exhibited a significantly higher grain yield of 11 - 22 %.

Farmers adoption of the modern wheat production technology in Egypt resulted in average annual wheat yield growth rate of 5.0 percent during 1980-99. However, the higher yield levels resulted in a greater profitability in wheat enterprise which makes wheat more competitive with other crops. The net farm income per unit area (feddan=4200m2) of wheat increased from LE. 93 in 1980 to LE.294 in 1986 and to LE.848 in 1999. Moreover, wheat acreage has become economically more feasible on marginal areas where there is an influential potential for further yield increases.

<u>Growth Stages and Maturity Categories :</u>

Growth stages of wheat plant are commonly known as seedling, tillering, jointing, booting, heading, flowering and filling as shown in Figure. The following is a brief summary for each of wheat stages:

Stage one
Pre-flag

1. Seedling – a young plant grown from seed to the stage when tillers emerge.
2. Tillering – shoots arising from the crown.
3. Jointing – nodes can be felt in the lower position of the stem but the head is not prominent in the leaf sheath.

Stage two
Early Boot

4. Booting – the head is prominent inside the upper leaf sheath and the flag leaf is developed.

Stage three
Late Boot

5. Heading – spikes are emerging but pollination has not begun.
6. Flowering – florets open and pollen is shedding (anthesis).

7. Filling – the fertilized ovary is enlarging and the kernel assumes full size.

Stage four ⇒ Milk – endosperm can be squeezed from the kernel as a white liquid.

Stage five ⇒ Soft dough – endosperm is becoming firm.

Stage six ⇒ Hard dough – endosperm is firm and the kernel changing color.

Stage seven ⇒ 8. Mature seed – kernel is firm and contains 35% or less moisture.

9. Fully ripe – kernel has about 12.5 % moisture.

Wheat Growing Days Required from Seed to Seed:

The number of growing days required for wheat cultivars to reach maturity varies depending on (1) variety , (2) date of seeding , (3) temperature, (4) moisture and fertility conditions . High temperatures and drought tend to force early heading . Seeding too late may force the crop into early heading and maturity , resulting in decreasing crop yield.

In general , the approximate growing days required from seed to seed for the majority of the commercially grown varieties is 170 days . However , days required from emergence to heading ranges between 70-90 days and 70-80 days required from heading to ripe stage.

The earliest variety Sids 4 requires 140 days from seed to seed . Sakha 61 requires 155 days.

Table (6) indicates the required days from seeding to reach various growth stages and development of the wheat plant under Egypt,s conditions.

Table F-2 : Main characteristics of the currently grown bread wheat cultivars

Cultivars	Number of spikes /m2	Number of kernels /spike	1000-kernel weight (gm)	Actual yield t/ha	Harvest index (%)
Sakha 8	350-450	50	42	5.0	32
Sakha 61	300-400	50	52	6.0	33
Sakha 69	350-450	50	48	6.3	32
Sakha 93	350-450	60	50	6.5	35
Giza 164	350-450	55	44	6.0	33
Giza 165	350-450	57	47	6.3	32
Giza 168	350-450	60	48	6.5	37
Sids 1	450-550	50	48	6.7	32
Gemmeiza 5	450-550	55	48	6.7	33
Sids 4	220-250	80	63	7.0	38
Sids 6	220-250	80	65	7.0	35
Sids 7	220-250	80	65	7.0	35
Gemmeiza 7	350-450	70	52	7.5	35
Gemmeiza 9	400-500	65	52	7.5	32

$$\text{Harvest index} = \frac{\text{Grain Yield}}{\text{Biological (Gross) Yield}} \times 100$$

Biological (Gross) Yield = Grain yield + Straw yield .

Source: Research Stations Data and Wheat Research Section, Field Crops Research Institute, ARC, MOALR, Egypt.

Table F-3 : Main characteristics of the currently grown durum wheat cultivars

Cultivars	Number of spikes /m2	Number of kernels /spike	1000-kernel weight (gm)	Actual yield t/ha	Harvest index (%)
Beni-suef 1	300-320	50	57	6.3	34
Beni-suef 3	320-360	53	53	6.3	36
Sohag-2	320-380	50	58	6.3	34
Sohag-3	300-350	50	60	6.0	36

$$\text{Harvest index} = \frac{\text{Grain Yield}}{\text{Biological (Gross) Yield}} \times 100$$

Biological (Gross) Yield = Grain yield + Straw yield .

Source: Research Stations Data and Wheat Research Section, Field Crops Research Institute, ARC, MOALR, Egypt.

Table F-4: Growth stages of the wheat plant and number of days from seeding to reach each stage .

Growth stages		Number of days from seeding
Stage 1	Germination	5-10
	Seedling	11-25
	Tillering	26-50
	Jointing (stem elongation)	51-70
Stage 2	Booting	71-80
Stage 3	Heading (ear emergence)	81-100
	Flowering (anthesis)	101-115
	Filling	
Stage 4 ⇨	Milk	116-130
Stage 5 ⇨	Soft dough (physiological maturity)	131-150
Stage 6 ⇨	Hard dough	151-165
Stage 7 ⇨	Mature seed	166-170
	Fully ripe	>170

Source: Wheat Research Section, Field Crops Research Institute, ARC, MOALR, Egypt.

ANNEX G: WHEAT YIELD FORECASTING RECOMMENDED TRAINING PROGRAM

Recommended Training Program

Basic Skills Training

This three part program is designed to provide training for staff in statistical organizations with emphasis on MALR, and to introduce data users to statistics as a valuable tool for planning and decision making. The Statistics training includes four courses and will equip staff in statistics offices to design surveys; select samples; train staff; collect, process and analyze data; make estimates and submit them to higher levels. Course four is for mangers and decision makers. The second component has four courses in advance training in applied objective yield survey design and operation. The third component is training in wheat pant characteristics and growth habits, Components two and three are primarily for survey field enumerators and laboratory staff. District and village level officers can also benefit from the training.

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The statistics courses are designed to provide general training in applied agricultural statistics. Although each course is a unit, they should be taken in sequence. All existing staff in MALR with responsibility for statistical program support, should complete statistics courses one, two and three. Course four is for managers and policy makers. New employees should be enrolled in the courses as soon as feasible after coming on board.

The advanced training in objective yield survey design and operation is for agricultural engineers with responsibility for wheat yield surveys. Although the design concepts of all objective surveys bear some similarity, the operational procedures are crop specific. The statistics courses cover the design concepts and operational methodology of various types of surveys in a general way. These courses focus specifically on wheat surveys.

The agronomic training is designed to give field staff a better understanding of basic plant physiology, growth habits developmental stages and factors affecting productivity. All agricultural engineers involved in survey field and laboratory work should complete this training.

Statistics Component

The statistics program includes four courses. Instructions are given through classroom lectures, discussions, exercises and field trips for demonstrations and observations. Courses one and three can each be completed in 25 hours; course two requires 50 hours; and course four is designed for 10 hours. Table (xx) below shows details of the subject matter covered in these courses.

<u>Course One, Introduction to Statistics</u> - Reviews the current system for collecting and disseminating statistics with emphasis on agricultural statistics. Review different kinds of surveys and their requirements and uses. Looks at the changing needs for statistics and the role of governments in meeting the need.

Course Two, Sampling and Methods of Statistics - Covers the principles and methods of survey design, sampling; data collection, processing, analysis, review and dissemination; and data quality.

Course Three, Operation of Statistical Systems - Applies the principles and methods of course two to design and develop operational plans for a demonstration survey.

Course Four, Data Needs, Uses and Standards - Reviews statistical systems, coordination and standards; statistics as a decision making tool; and, the impact of accurate or (inaccurate) statistics on government and private sector decision making.

Table G-1: Statistics Training, Course Outline and Training Topics
Course One

Introduction to Statistics
Importance of statistics
Terms and definitions
Uses of statistics
Benefits to farmers, government, and private sector
Types of surveys
• Sample surveys
• Censuses
• Research and case studies
Sampling
Survey procedures
• Data collection
• Data processing
• Reviewing and editing data
Normal distribution and histograms
Frequency distribution
Data handling procedures
Using survey data
Importance of accuracy
Forms and instructions
Interviewing techniques
Probing techniques
Developing relationships with farmers
Confidentiality of survey data

Table G-2: Statistics Training, Course Outline and Training Topics
Course Two

Sampling and Methods of Statistics
Key terms and definitions
Types of surveys
Sample surveys
Censuses
Sampling frames
Constructing and maintaining frames
Sampling methods
Choosing the proper sampling method
Steps in selecting a sample
Subjective surveys
Area surveys
Cost of production and household surveys
Objective surveys
Crop cutting
Surveying for forecasting
Survey design
Determining what information to gather
Sample design
Field survey procedures
Training
Data processing
Data review and editing
Data analysis
Using survey data
Computing survey indications
Computing variances
Sampling error
Non-sampling error
Making inferences from survey data
Importance of timeliness
Managing the survey process
Storing and preserving survey data
Equipment needs

Table G-3: Statistics Training, Course Outline and Training Topics Course Three

Survey Design and Operation
Survey design
Equipment needs
Sample design
Sample selection
Forms and Instruction manuals
Training
Survey operation
Data handling, processing, summary, and analysis
Critique the process

Table G-4: Statistics Training, Course Outline and Training Topics - Course Four

Data Needs, Uses, and Standards
Who needs statistics
Uses of statistics
Understanding the process
Sample surveys
Censuses
Forecasts vs estimates
Importance of accuracy
Importance of timeliness
Storing and preserving data
Responsibility for statistical systems
Statistical standards
Data integrity
Support for statistics
Budgetary considerations
Political implications

Objective Yield Survey Procedures Component

The objective yield survey procedures component includes four courses. Courses one, two and three target specific groups of the staffs working with objective yield surveys. Course four is advanced training for staff who analyze survey data and make forecasts and estimates based on the data. There is some overlap of subject matter between this component and the statistics courses outlined above. The statistics courses treat the subject matter in a general way, and this component focuses narrowly on objective yield survey applications. These courses do not eliminate the need for annual objective yield survey training, but will reduce the length and intensity of the annual survey training. Table (xx) below shows details of the subject matter covered by these courses.

Course one and course four require 16 hours for completion. Courses two and three can be completed in eight hours.

Course One, for Enumerators - This course is for all field enumerators and supervisors. It is also recommended for engineers responsible for the survey laboratory activities and data analyzers.

Course Two, for Field Supervisors - Requisite, Course One. Covers supervisor responsibilities, controlling non-sampling error, and report writing. Reviews agriculture policy that needs reliable and timely statistics for informed decision making.

Course Three, for Laboratory Staff and Field Supervisors - In addition to laboratory procedures and equipment, this course covers the importance of precision and special counts and measurements for yield forecasting research.

Course Four, for Data Analysts - Requisite, Course One, Two or Three, reviews different sampling methods and covers the principle steps in the methods used for selecting samples for forecasting surveys. Covers data review and analysis, the different estimators (indications) that can be computed from the survey data, sources of sampling and non-sampling error, and making forecasts and estimates from survey data.

Table G-5: Survey Procedures Training - Course Outline and Training Topics

Course One
Terms and definitions
Benefits of forecasts
Why objective yield
Sample selection
Cluster selection
Parcel selection
Field selection
Plot location
Field survey procedures
Equipment need, uses and care
Basic plant physiology
Factors affecting yield
Data collection – counts and measurements
Maturity stages
Forms
First field visit - late January
Second field visit – late February
Third field visit - late March
Fourth field visit – late April
Harvest yield
Post harvest gleaning
Problems, constraints and solutions
Course Two
Wheat yield forecasting and agricultural Policy
The main job of supervisors
Data evaluation
Types of error
Reducing non-sampling error
Understanding sampling error
Scheduling work
managing people
How to write a report
Importance of consistency of operations across governorates
Course Three
Importance of laboratory measurements
Data collection and information flow
Importance of precision

Implications of small laboratory errors
Laboratory forms
Instruction manuals
Laboratory equipment
Handling field samples
Counts and measurements
Special measurements for forecasting research
Course Four
Review and theory of sampling
Simple random sampling
Stratified random sampling
Multistage random sampling
Systematic random sampling
Advantages of different sampling methods
Principal steps in sample selection
Regression estimates
Ratio estimates
Crop cutting - design and procedures
Crop yield forecasting
Sample design
Survey procedures
Data summary and analysis
Regression models
Survival ratio models
Biological yield
Economical yield
Net yield
Total production
Analysis of variance
Standard error of estimates
Types of error
Sampling error
Non-sampling error
Evaluation of forecasts
Managing the process
Making inferences from sample data
Area surveys and estimates
Data integrity
Storing and preserving data
Policy and political considerations

Agronomic Component

Much of the proposed agronomic training can be accomplished through participation in regularly scheduled field days at agricultural research stations. Research stations conduct field days several times each year to showcase the results of their research and plant breeding programs. Through these sessions, the new technology is transferred to the production level through the agricultural extension agents. Information on new varieties, cultural methods, enhancements and constraints to productivity, and other changes is disseminated at these field days. By taking part in this program, MALR agricultural engineers can increase their knowledge of plant culture and stay abreast of changes in varieties being grown and agricultural practices. Additional crop specific training on growth habits and plant development stages can be arranged through the research stations to complement the survey procedures training for objective surveys.

The intensity of this kind of training can be reduced as the staffs become knowledgeable about plant characteristics and growth habits, but will never disappear completely. New employees need the training and all agricultural engineers responsible for survey field and laboratory work need periodic refresher courses.

ANNEX H: WHEAT YIELD FORECASTING FIIELD TRIP REPORTS

Report of the First Field Visit (Summary of Activities)
Late Ten Days of January 2000

Objective of the visit:

1. Enumerator training in the Governorate of the study.
2. Layout plots within samples.
3. Data collection.
4. Link between Agriculture Research Station and the Statistical Offices of the Governorates.

Achievements of the visit:

Table (H-1) summarizes the achievements of the period from January 22nd till February 7th, 2000.

Main points are explained as follows: -

A. Training:

1. Technical aspects of wheat plant conducted by wheat researchers from the Agriculture Research Station within or close to Governorates of the study. The training includes a lecture in the Research Station followed by field visit to the research farm.
   The lectures focused on wheat plant characteristics, wheat varieties, growth stages factors affecting wheat growth and productivity like weather, diseases, insects, herbs,…etc. Wheat Crop Triangle was also explained (Number of spikes, number of kernels per spike and weight of kernels), the trainees received a written material in Arabic.
   The lecture lasted about 2 hours followed by field training in the Research Station farm for wheat growth stages and varieties discrimination.

2. Statistical training for wheat yield forecasting by the study team members, the training includes:
   - Sample selection.
   - Diagram of parcels and fields randomly selected, dimension measurements.
   - Locating plot within fields randomly.
   - Plot layout, 60cm x 60cm for count area and 60cm x 60cm for clip area. Determination of clip areas, 30cm x 20cm.
   - How to determine the code of wheat maturity stages, (1) Pre flag, (2) Flag and early boot, (3) Late boot or flower stage, (4) Milk stage, (5) Soft dough stage, (7) Ripe stage.
   - Data collection by form (B), Stalk number, late boot numbers, emerged head number, in count area.
   - Answer questions of the trainees (enumerators) suggest solutions for some problems that they may face during the data collection. After the lecture, the trainees applied the training on sample fields of the study, and started to do their job under supervision of the supervisors and everybody received a work manual in Arabic.

B. Layout plots and data collection:

After each training, the team started to layout plots and collect data, the work was done according to the previously scheduled plan as mentioned in table (H-1) except for Beheira and New lands because of bad weather and heavy rains. During this period, the team members supervised all steps of sampling starting from cluster (PSU) selection, random selection of 2 wheat parcels within cluster (one field within parcel), random location of 2 plots within field and layout the plots and data collection.

The maturity stages of wheat during this visit were ranged between code 1 and 2. Therefore, data collection concentrated on stalk numbers.

<u>The most important problems that faced the team during this visit were as follows:</u>

1. Having no map for the primary sampling unit (A cluster of about 200 Feddan of cultivated area in average) made it very difficult for us to reach the selected wheat parcels, as happened before in Fayoum district, Monshaat Abdallah, cluster number 268 Hode El-Zore, wheat parcel of the cultivator Ramadan Mohamed Ismail (January 22, 2000). In Sharikia governorate, Dyarb Nigm district, Magaffif village, cluster number 84 Hode Gharby 2, parcel of the cultivator Ahmed Mohamed Ismail,, we discovered that they met the selected name but not the one in the selected cluster (instead of the proper wheat parcel). We think that this wouldn't happen if they used the survey list (form 3) and a map of the selected cluster and selected parcels within cluster was available.
2. Another reason for not obtaining the needed information easily was that the names of the selected wheat parcels were for the owners not for the cultivators of the crop.
3. The fields, which are not properly divided according to field dimensions, are considered a problem. It is essential to train the enumerators on how to divide parcels to fields, field dimensions, and random selection to locate plots, using diagrams and field sketches.
4. Ditches width, which divide parcels into fields, should be reconsidered to be 25 cm instead of 50 cm used for crop cutting in wheat forecasting.
5. The enumerators need to be trained very well on locating and layout the plots using frames and other equipment and on how to count without damaging the plants.
6. To prevent stalks damage, no more than two enumerators have to be inside the field to layout and count the stalks.
7. There were some problems with maturity stages, especially between pre-flag (code 1) and flag (code 2) stages.
8. It is better to start plots layout by the beginning of January. Stalks may be damaged partially and determining stalks belonging to the plot precisely may be difficult if plots layout took place in late January (about 50% of the sample was in maturity stage 2 in late January).
9. Some difficulties with diseases identification and herbage.
10. Difficulties to obtain information from the selected cultivator in the sample as he was usually not available during the visit.

11. Not enough cooperation between the local agricultural staff and the forecasting enumerators.
12. A new designed forms for collecting wheat forecasting data should be generated with clear instructions, as the old ones are not suitable.
13. The Lab equipment are insufficient especially the electronic balances, ovens and humidity measurement equipment.
14. Bad weather could affect and prevent conducting the field work as happened before in Noubaria on the 26th of January.

C. Suggestions:

- More technical and statistical training for the enumerators.
- Field training by both the wheat researchers and the Forecasting Station.
- Using different flag colors to distinguish between plot (1) and plot (2) within the field.
- Use an ID card for every plot written with graphic pencil.
- Provide enumerators with forecasting equipment.
- Supervisors should supervise all sampling stages starting from the cultivator surveys, parcels and fields selection, plot location and layout, to data collection…etc.
- Design new forms for collecting data and lab measurements.

<u>The team has designed new 5 forms (in Arabic):</u>

1. Form (A) for cluster mapping and parcel diagram.
2. Form (B) for stalk, late boot, emerged heads count, and clip area…etc.
3. Form (C-1) for lab, clip area sample.
4. Form (C-2) for lab, harvest count area data and lab measurements.
5. Form (E) Post-harvest gleaning.

D. Results:

Table from (H-1) shows the results of the first visit (late January) for the governorates of the study (6 governorates), the most important variable is the stalk numbers for about 110 plots.

Table (H-1): Wheat Forecasting 2000
Training Plan and First Visit Achievements of the Study Team during the Period from 22 January – 7 February 2000

Date	Governorate & Agric. Research Station	Subject of Training & Field Work Achievements	Trainers
22 Jan. 23 Jan.	Fayoum Sedse, Agric. Research Station	Explain form B and data collection, layout samples of Fayoum district. Technical training on wheat crop, maturity stages varieties…etc. by wheat researchers. Trainees: Fayoum enumerators.	Dr. Morsi Dr. Ramzi Dr. Abdel Salam Dr. Saied Khalil Mr. Agati
24 Jan. 25 Jan.	Assuit	Technical training on wheat (crop) plant. Explain form B for data collection, field training in Assuit district. Layout and data collection of Dyrout district samples. Trainees: Assuit enumerators.	Dr. Morsi Dr. Ramzi Dr. Mousa Girgis Mr. Abdel Razic Mr. Agati
27 Jan. 28, 29 Jan.	Noubaria, Agric Research Station. Beheira, New Lands	Technical training on wheat plant. Explain form B for data collection and sampling. Trainees: Beheira, Busttan and Amerya enumerators. Field training was postponed as a result of bad weather.	Dr. Morsi Dr. Mostafa Asab Dr. Ramzi Mr. Abed Mr. Agati
30 Jan. 31 Jan.	Sakha, Agric. Research Station Kafr El-Sheikh	Technical training on wheat plant. Explain form B for data collection and sampling techniques. Field training in Kafr El-Sheikh district. Layout samples of sidi Salem district and data collection Trainees: Kafr El-Sheikh enumerators.	Dr. Morsi Dr. Abdel Salam Dr. Omar Dr. Ramzi Mr. Sied Mr. Agati
1 Feb. 2 Feb.	Gemmiza, Agric. Research Station Gharbia	Technical training on wheat plant. Sampling techniques, wheat forecasting, data collections by form B. Trainees: Gharbia & Sharkia enumerators. Field training in Zefta district. Layout samples in Tanta & Zefta districts.	Dr. Mostafa El-Minoufi Dr. Ramzi Dr. Asaad Mr. Abed Mr. Agati
3 Feb.	Sharkia	Layout and collect data of all samples of Zagazig & Dyarb Nigm districts in Sharkia governorate.	Dr. Morsi Dr. Ramzi Dr. M. Abed
5-6 Feb. 7 Feb.	Beheira New Lands, Busttan & Amerya	Layout and collect data of all samples of Damanhour & Delengat districts. Layout and collect data of all samples of Busttan & Amerya in New Lands.	Dr. Morsi Dr. Ramzi Mr. Saied Gad El-Moula

Report of Second Field Visit (Summary of Activities)

Late January, 2000 (22 February – first of March)

<u>Objectives of the visit:</u>

1. Training.
2. Data collection for the second visit.
3. Supervision of the field work.
4. Link between wheat researcher and the teamwork.

<u>Achievements of the second visit:</u>

Table (H-2) summarizes the achievements of the second visit from 22 February to first of March, 2000, for the governorate of the study.

Main points are as follows:

A. Training:

- Explain the instructions of the second visit and the use of new form (B) for data collection, stalks number, late boot spikes, emerged heads, clipping areas…etc.
- Field training for data collection under the supervision of the team and wheat researchers including determination of wheat maturity stages, wheat varieties discrimination, diseases and insects affect on wheat crop, the main herbs which grows within wheat crop, stalks, late boot, emerged heads count, clipping areas, emerged head sample…etc.
- Training of the supervisors to follow up fieldwork of the enumerator and how to write useful reports.
- Train the lab staff on sample measurements from clipping areas, weight of emerged heads, count of fertile spikelets, sterile spikelets…etc.

B. Data Collection:

Under the supervision of the teamwork the enumerators collect data of form (B) for all samples in the governorates of the study. This form includes beside identification information, (1) method of plantation, (2) unit location, (3) stage of maturity and count within units, (4) stalks (stems), (5) late boot, (6) emerged heads-detached heads at harvest, (7) use of maturity code to follow up work, (8) within clip area for emerged head sample for lab measurements. Also, form (B) includes additional information about wheat plant height, flag leaf length and width and information about main factors affecting wheat yield.

About fifty percent of the sample in the second visit was in the late boot or flower stage (code 3), therefore, we used clip areas number (1), and the rest was in flag stage (code 2). Table (H-2) shows the results of the data collected and lab measurements.

C. Problems:

1. Irrigated fields make it very difficult to collect data on the same day of visit as happened before in a field in Dyarb Nigm district, Mogaffif village. Ahmed Mohamed Ismail field on February 28 and in Delengat district, Tiba village in the field of the farmer Ibrahim Afifi Ghanem. On February 29, we had to stay a couple of days more until we could get inside the field.
2. Most of identification information written on colored flags for plots were omitted, it is better to write such information with graphic pencil or by a fixed flomaster pen.
3. Some plot remarks were broken.
4. Only one field in Mogaffif village, cultivator Ismail pulled out stalks and flags, the plots layout had to be done again.
5. Some stalks were destroyed during the area count and within field, no more than two enumerators should get into the field
6. After maturity stage (3), there were some difficulties to split the unit to clip area or count area to 4 areas to facilitate counts. It seemed to be more easy and save with plots that had been divided in previous visits with stalks and strings.
7. Some mistakes happened in the number of plots between the first and the second visit.
8. Bad weather may affect doing proper work in proper time.

D. Remarks and Suggestions:

1. It is better for the enumerator to have equipment in small bag.
2. It is better to ask the cultivator about the irrigation data to avoid visiting in an unsuitable time.
3. It is better to layout unit (1) in the first half of the field randomly and unit (2) in the second half of the field randomly.
4. Use a colored red flag for unit (1) and a white one for the second unit and write an ID card for each.
5. It is better for the enumerator to write identification data for form (B) in the office before visiting fields, this can save time and prevent many mistakes of identification.
6. Management and work organization is very important for perfect work.
7. Source of seeds is an important question for the cultivator.
8. It is important to follow up all the items of form (B) from item (1) to item (10).
9. For qualitative questions in item no. (10) it is better to give a degree for every level.
10. Modify form (B) as a result of visit (2) remarks.
11. What could we do when clip area is blank? Could we take another one from outside the unit?
12. The sterile spikelets usually at the base of the spike.
13. Some hormones, like T4D, of herbs affect spikes.
14. Diseases appear more often in fields cultivated with seeds by cultivators.
15. We have to design ID tag for lab sample.
16. More training for lab staff, more equipment is needed.
17. Enumerators in governorates are ready to have more training and more education on forecasting.

Table (H-2): Wheat Forecasting 2000
Training Plan and Second Visit Achievements of the Study Team during the Period from 22 February – 1 March 2000

Date	Governorate & Agric. Research Station	Subject of Training & Field Work Achievements	Trainers
22 Feb.	Fayoum	Explain the new form B to collect data for the second visit. Field training on maturity stages, stalks, late boot, emerged heads counting, clipping, in Fayoum district.	Dr. Morsi Dr. Ramzi Mr. Sied Mr. Agati
23 Feb.	Assuit	Same training plus field training in both Assuit & Dyrout districts.	Dr. Morsi Dr, Ramzi Mr. Abdel Razic Mr. Agati Dr. Mousa Girgis
26 Feb. 27 Feb.	Kafr El-Sheikh Kafr El-Sheikh	Same training, fieldwork in Sidi Salem district. Data collection of Kafr El-Sheikh district samples.	Dr. Morsi Dr, Ramzi Mr. Agati Mr. Abed
27 Feb. 28 Feb.	Gharbia Gharbia	Same training, collect data of Tanta district samples. Data collection of Zefta district.	Dr. Ramzi Dr. Asaad Mr. Agati
28 Feb. 29 Feb.	Sharkia Sharkia	Same training, collect data of Dyarb Nigm district samples. Collect data of Zagazig district samples.	Dr. Ramzi Dr. Asaad Mr. Abed
29 Feb. 1 March	Beheira Noubaria	Same training plus collecting data of Damanhour & Delengat districts. Same training plus collecting data of Busttan & Amerya New Lands samples.	Dr. Morsi Dr. Ramzi Dr. M. Asab Mr. Abdel-Razik Mr. Saied G. El-Moula

Report of the Third Field Visit (Summary of Activities)
March /April, 2000

1st) Objectives of the Visit

1- Training
2- Data collection for the third visit
3- Supervision of the field work
4- Link between wheat research and the teamwork

2nd) Achievements of the Third Visit

The training schedule for March was slightly different from the previous month due to wheat maturity stages. Field activities for March stated in Kafr El Sheikh on 23 of March and ended on April 02 in Nubaria. Table (H-3) summarizes the achievements of the third visit.

The March training concentrated on the maturity stages (milk and soft dough) from both technical and data collection sights, using adjusted new Form B developed since the February field work was completed. ID Card was developed for laboratory samples. The training includes how to determine the maturity stages, how to count emerged heads in count areas and clip stems in clip areas, how to avoid plant damage and be sure to fill all Form (B) data.

Form (B) in this visit has the same items of the previous visit but with better organizations and definition of questions.

Most of the sample fields (about 60%) were in the milk and soft dough stages at the time of the late March visit. About 40% still in the flowering stage specially in Sharkia and Fayoum. Clip area number 2 was harvest for samples in maturity stage 4 or 5.

The trainers emphasize the trainees to collect all data that had not been collected in the previous visits concerning the main factors affecting wheat yield samples, as previous crop, seed source and rate, planting date and method, variety, irrigation, fertilizer, weeds, insects, diseases, …… etc.

Improved seeds may increase yield by 3-4 Ardab/Feddan.

Variety Sakha 69 is the common variety which cultivators prefer to cultivate because his wide adaptability allover the country (not less than 60% of wheat total area). It's potential yield is about 20 Ardab/Feddan. Under Cultivator circumstances, the yield may decrease to about 18 Ardab/Feddan.

Planting date: Early planting, means early flowering with February cold which affect spikes, increase sterile spikelets, some was seen in Sidi Salem district in Kafr El Sheikh and in Fayoum district in Fayoum governorate.

Weather: We can not control weather but other factors like irrigation, fertilizer, … etc. Stormy wind blew on 23rd of March made wheat plant lodging in some fields specially that were irrigated soon.

Yellow Rust Spots were detected in some fields within some governorates (Kafr El Sheikh, Sharkia, and Assuit). It will not affect the yield so much due to late infestation and high temperature (yellow rust could decrease wheat yield by about 20% at the beginning of infection, and about 70% after one week).

Lab Staff Training: Lab staff in both Gharbia and Assuit had special training on sample measurements, explain Form C-1, conduct a practical sample, using electronic scales and special lab equipment.
Assuit' lab staff were told to conduct a special research raised by Dr. Abdel Salam and Dr. Mossa (wheat researchers) to test the equality with the final yield. Also to test the possibility of drying spike samples to facilitate kernels counting.

3rd) Problems and Modification

1- All stakes of some plots were pulled out. Solution: layout the plot in the same location. Increase the cultivator's awareness to protect plots.

2- Wheat plant damage within sample demonstration training plots. Solution: do not use sample plots for demonstration training. Use separate additional plots.

3- Difficulties in finding plots within fields because the colored flags were not found or they were too short to appear. Solution: use strong and taller color flags beyond south west corner of the plot by one meter.

4- Stem damages when dividing plots for counting and clipping. Solution: mark and divide both counting and clipping areas during the first visit in January when plots and stems are short, use white colored plastic strip (string).

5- Difficulties in finding sample parcels and fields in new lands because of large wheat cultivated areas and similarity of all parcels. Solution: good diagram (kroke) for selected areas, fields, and plots within fields. Stratified multistage sampling in new lands must be modified.

6- Difficulties of obtaining cultivator' information or interview. Solution: make a special visit or interview to the cultivator with previous appointment to obtain all information needed.

7- There is no oven in the lab of Gharbia. Solution: move one or two ovens of Assuit lab to Gharbia.

8- Governorate enumerators asked for more information on crop forecasting and for new equipment. Solution: prepare a training program to the second season, one for enumerators and the other for analyzers. Renew and buy new equipment.

Table (H-3): Wheat Yield Forecasting
Training Plan and Summary of Third Field Visit Activities
23rd of March – 6th of April, 2000

Date	Governorate	Trainers and Supervisors	Subject of Training and Fieldwork Activities
03/23	Kafr El Sheikh	Dr. Morsi Dr. Ramzi Dr. Abdel Salam Dr. Mossa Guirguis Mr. Abed Mr. Agati	Explain modified Form (B) for data collection of the third visit. Explain wheat maturity stages. Count emerged heads and late boot heads in counting area. Clipping samples (field work). Technical training on wheat maturity stages (milk and soft), wheat diseases, insects and factors affect wheat plant in these stages. Answer all questions raised by enumerators during field work. <u>Trainees:</u> About 50 trainees for all governorates (8 each).
03/25	Sharkia	Dr. Morsi Dr. Ramzi Dr. Asaad Mr. Abed Mr. Agati	
03/26	Gharbia	Dr. Morsi Dr. Ramzi Dr. Asaad Mr. Abed Mr. Agati	
03/28	Fayoum	Dr. Morsi Dr. Ramzi Dr. Sayed Khalil Mr. Gad El Mowla Mr. Agati	
03/30	Assuit	Dr. Morsi Dr. Ramzi Dr. Mossa Guirguis Mr. Gad El Mowla Mr. Agati	
04/01	Beheira	Dr. Morsi Dr. Ramzi Dr. Mostafa Azab Mr. Gad EL Mowla Mr. Agati	
04/02	Nubaria	Dr. Morsi Dr. Ramzi Dr. Mostafa Azab Mr. Gad EL Mowla Mr. Agati	

Report of the Forth Field Visit (Summary of Activities)
April - May, 2000

Objectives

1- Training field enumerators and laboratory staff.
2- Data collection for the fourth visit.
3- Count area harvest in maturity stages 6 or 7.
4- Supervision of the field work.
5- Promoting teamwork between the wheat researchers and the sampling offices.

Achievements

The training schedule for April was largely different from the previous month due to count area harvesting in about 78% of the sample plots due to maturity stages hard dough (6) and ripe (7).

The April training concentrated on harvesting count area in wheat crop maturity stages 6 and 7 from both a technical and data collection viewpoint, using Form (B). An ID Card of harvesting was developed to record number of clipped heads. The training concentrated on how to determine the maturity stages of plot harvest count and clip mature heads in count areas. Clip area number three was harvested for samples in maturity stages 4 or 5. Enumerators were encouraged to take care in recording counts and harvesting before leaving the sample field. Also they were told how to conduct post-harvest gleaning of wheat crop in the same sample fields.

Lab staff in both Gharbia and Assuit had special training on sample counts, harvest of count areas, using forms (C-1), (C-2), and (C-3), using the electronic scales, ovens for drying samples. They also had a live practice with processing wheat threshing, kernel separation and moisture content measurements (see table H-4).

Observation, Comments, and Problems

1- Some sample cultivators had harvested wheat crop in maturity stage (5) soft dough (to plant paddy), let it dry under sun in the field. We had to harvest our sample with high moisture content. But spike peduncle and plant leafs become yellow.
   Solution: No problem if harvest samples were dried enough by oven to measure moisture content. Wheat researchers said that if the spike peduncle was dries we can harvest because there is no more starch precipitation, it is just more moisture content in the grains.

2- Vegetables planted under wheat crop need continuous irrigation. Ripened wheat grains seems to be in the soft dough stage with high humidity (Dayrout El Sherif – Assuit).
   Solution: Look carefully to the spike peduncle and the wheat plant leafs and if it were yellow then harvest count area, put it in the oven till dry, then thresh and weight … etc.

3- Some green spikes appear within the harvest visit in plot sample due to plant lodging or plant damage.
   Solution: Count and harvest all and write in the form (B) and ID Card remarks number of the not mature spikes for these reasons.

4- Damage of sample plots used for demonstration training.
   Solution: Use additional and separated sample plots for demonstrations.

5- Sample plot destroyed by cultivator.
   Solution: Explain objective of plot sample to cultivators and ask them not to destroy or damage or pullout stakes of plots.

6- Spend much time searching for sample field.
   Solution: Maps for primary sampling units (clusters) determine selected parcels and fields.

7- Post-harvest gleanings before cultivator take out wheat crop from the field.
   Solution: Take harvest loss after cultivator harvesting, take out and pick up remain spikes under the ground. The enumerator should ask the cultivator for that.

Special Problems for Lab

With the gleaning of plot harvest in maturity stages 6 and 7, both labs of Gharbia and Assuit have to work hard.

1- Too much work in short period, some times to work for 24 hours per day.
   Solution: Train more people for lab work.

2- Lack of equipment makes work difficult specially for threshing the crop and drying samples.
   Solution: Buy small thresher machine for every lab and a laser measurement equipment of moisture content instead of ovens.

3- Lab receives samples too late from other governorates.
   Solution: Organize sending samples from other governorates to the lab center.

4- Receiving destroyed samples affect the accuracy of measurements (stalks number, grains per spike …etc.)
   Solution: Use suitable bags for samples, handle with care, ask enumerators to put spikes with the right way.

5- Grains waste (lose) during sample clipping and harvesting specially with Durum wheat and Sakha 69 varieties.
   Solution: Do not leave samples without harvesting till dead ripe stage. Samples should be harvested in hard dough stage (6) or in ripe stage (7). Also spikes must be handled with care, and you must collect any lost grains.

Table (H-4): Wheat Yield Forecasting
Training Plan and Summary of Fourth Field Visit Activities
April 22 – May 02, 2000

Date	Governorate	Trainers and Supervisors	Subject of Training and Fieldwork Activities
04/22 04/23	Kafr El Sheikh	Dr. Morsi Mr. T.J Dr. Ramzi Mr. Abed Mr. Agati Dr. Mossa Guirguis (Wheat Researcher) Mr. Abed	A- Office and field work training includes: - Statistical and technical training on wheat maturity stages 6 (hard dough) and 7 (ripe). - Count and harvest wheat samples. - Record data on form (B) and ID Harvest Card. B- Special training for lab staff, 5 in Gharbia and 3 in Assuit. Count and check spikes received, numbers, weight, thresh, weight before and after drying, proper use of ovens, count kernels per spike … etc. Record data on forms C-1, C-2 and C-3 C- Post-harvest gleaning training on how to collect and record on form (E), and lab measurements.
04/24 04/25	Gharbia	Dr. Ramzi Mr. Abed Mr. Agati Dr. Asaad (Wheat Researcher) Mr. Abed	
04/25 05/02	Beheira	Dr. Morsi Mr. T.J Dr. Ramzi Mr. Gad El Mowla Mr. Abdel Razik Dr. Mostafa Azab (Wheat Researcher) Mr. Gad El Mowla	
04/25	Sharkia	Mr. Abed Mr. Agati Dr. Asaad (Wheat Researcher)	
04/27	Fayoum	Dr. Morsi Mr. T.J Dr. Ramzi Mr. Gad El Mowla Mr. Agati Dr. Sayed Khalil (Wheat Researcher)	
04/28- 04/30	Assuit	Dr. Morsi Mr. T.J Dr. Ramzi Mr. Gad EL Mowla Mr. Abdel Razik Mr. Agati Dr. Mossa Guirguis (Wheat Researcher)	
05/02	Nubaria	Dr. Morsi Mr. T.J Dr. Ramzi Mr. Abdel Razik D. Mostafa Azab (Wheat Researcher)	

Harvest Visit
Maturity Categories 6 and 7 (Hard Dough & Ripe)

Actual number of heads and actual head weight are used to calculate gross yield per area. The following final lab data and gleaning measurements of post harvest grain, are obtained for a plot:

* Number of emerged heads, detached heads, and heads in late boot	= 132.7
* Number of head threshed	= 131.9
* Threshed weight of kernels (12.5%)* moisture content	= 245.2 gm.
* Post-harvest gleaning kernels 12.5%	= 2.4 gm.

Calculate weight per head, gross yield per feddan, harvest loss and net yield:

* Weight per head = (threshed weight of kernels 12.5%)/number of heads threshed
= 245.2 / 131.9 = 1.85898 gm.

* Gross yield per feddan = (number of heads) (weight per head) (conversion factor)
= [(131.9) (1.85898)] [0.07778]
= 19.07 Erdab

* Harvest loss per feddan = weight og threshed kernels 12.5% conversion factor
= (3.38) (0.07778) = 0.26 Erdab/feddan.

* Net yield = gross yield – harvest loss
= 19.07 – 0.26 = 18.81 feddan (4200 m^2)

* Adjusted net yield for utility coefficient of feddan 0.95 of feddan
= (18.81) (0.95) = 17.87 Erdab/feddan (3990 m^2)

From plot weight to feddan yield:

$$\text{Conversion factor} = \frac{4200\ \text{m2 (fed./area)}}{0.36\ \text{m2 (plot area)}} \quad \frac{1}{1000\ \text{gm. X } 150\text{kg. (weight per Erdab)}}$$

= 0.07778

* Threshed weight of kernels 12.5%:
= [threshed weight of kernels (1.0 – moisture content)]/0.875

Table (H-5) Harvest Visit
Maturity Categories 6 and 7 (Hard Dough & Ripe)

Item	Unit	Average	S.E %	(0.05) Lower Limit	(0.05) Upper Limit
Number of heads per plot.	No.	131.9	2.68	124.925	138.875
Average weight of kernels (12.5% moisture)/head	Gm.	1.859	3.02	1.746	1.972
Average weight of kernels (12.5% moisture)/plot	Gm.	245.2	3.68	227.34	263.06
Conversion factor from plot to gross yield/feddan	Coeff.	0.07778	-	-	-
Gross yield per feddan	Erdab	19.07	3.68	17.68	20.46
Harvest loss per feddan	Erdab	0.26			
Net yield (4200 m^2 feddan)	Erdab	18.81		17.08	20.20
Utility coefficient of feddan (2990 m^2)	Coeff.	0.95	-		
Adjusted net yield to feddan 3990 m^2.	Erdab	17.87		16.23	19.19